EXHIBIT A

From: David Hall
To: Flynn, Gerry; Frank W. McCrackin
Cc: Joe Fox ; Tyson Wilde ; Philip Townsend ; Gary Peterson ; Jeff Crockett ; David Hall
Sent: Fri Sep 16 23:56:06 2011
Subject: Notice of Infringement of Novatek Patents by both CAT and E6
Gerry and Frank:

Our field people have made me aware of Road Milling that (CAT and E6) have been doing for the past few months that uses diamond enhanced picks that are in violation of one or more of Novatek's granted US Patents.

We request that you cease immediately any use these diamond enhanced picks as they infringe Novatek's patents.

We have informed CAT that they are infringing and they have told us that E6 claims that the picks that CAT is using are covered by E6 patents.

CAT has refused to conduct their own independent evaluation to determine if they are infringing.

CAT has also informed us that they are not in a position to provide us with any more details about the pick because of a confidentiality agreement with E6.

We do not have physical access to any of the picks under question... and so our observations are based on visual inspection.....

If either E6 or CAT could send us more information about the picks that you are jointly using..... that would help both of us determine the extent of the infringement issue.

It would also help both CAT and E6 learn more about Novatek claims that might help you create a design that does not infringe Novatek patents.

Thanks and best regards to both of you.

David R. Hall
President
Novatek Inc.

EXHIBIT B

Sent: 21 September 2011 18:38
To: David Hall
Cc: Frank W. McCrackin; Flynn, Gerry
Subject: Notice of Alleged Infringement of Novatek Patents by both CAT and E6

Dear Mr Hall

I refer to your email sent 16 September 2011 to our Gerry Flynn (copied below), which has been forwarded to me for attention.

We do confirm that we are carrying out some tests of our experimental PCD road planing picks with a potential customer, but are unable to provide any details of the tests or the experimental picks as these tests are being carried out under a mutual Confidentiality Agreement (as correctly indicated in your email).

However, we are concerned to receive your email alleging infringement by Element Six (as well as CAT) of Novatek patents and would like to investigate this allegation. You mention infringement of 'one or more of Novatek's granted US patents' but do not state which actual patents you are referring to. We ask that you provide us with a list of the patents that you consider infringed, so that we can conduct our own evaluation. It would also be helpful if you could provide further reasoning as to why you consider the diamond-enhanced picks to be infringing the patents.

I look forward to receiving your response.

Regards

Susan Fletcher Watts
Group Head of Intellectual Property
Patent Attorney

Element Six Group

EXHIBIT C

From: David Hall [mailto:dhall@novatek.com]
Sent: 18 October 2011 15:36
To: Fletcher-Watts, Susan
Cc: Flynn, Gerry; Joe Fox; Philip Townsend
Subject: Need details of the E6 parts being used in Eastern United States:

I missed it when sent.. but got the copy from Gerry on the 28th..

We are working on our response.. We have visual inspections of your parts that are being used commercially in the Eastern part of the United States... What is holding us up is obtaining details on the design of your parts as we have visual observations but do not have physical posession of a part in order to make measurements so that we can be precise in our description of your infringement.

If you could send us drawings and specifications of the parts that are being used on road construction in the United states that would help us let you know the details of your infringement. You have all of the dimensions and specifications of our parts as you had access to that information during our discussions with you about purchasing the technology.... These details are shown and repeated in one or more of your published patent applications.

Thanks

David

EXHIBIT D

November 15, 2011

Susan Fletcher Watts
Group Head of Intellectual Property
Element Six Group
3rd Floor, Building 4 Chiswick Park
566 Chiswick High Road, London W4 5YE

Re: Diamond Enhanced Road Milling Picks Patent Notice

Dear Mrs. Watts,

It has been brought to our attention that Caterpillar Inc. and Element Six Group are performing road milling using diamond enhanced picks that violate U.S. patent rights owned by Novatek Inc.

For example, Novatek Inc. owns the exclusive rights to U.S. Patent No. 7,384,105; U.S. Patent No. 7,665,552; U.S. Patent No. 7,353,893; U.S. Patent No. 7,469,756; U.S. Patent No. 8,028,774; and U.S. Patent No. 7,669,674 for this field of use.

Novatek Inc. also owns pending U.S. Pat. App. No. 13/208,103 as well as others. Such patents and pending applications claim various embodiments of diamond enhanced picks as represented by the attached selection of figures.

Based upon Element Six Group's prior relationship with Novatek Inc., under a confidentiality agreement (see attached), Element Six Group is aware of this technology and Novatek Inc.'s ongoing research and development in this field.

We will appreciate very much your attention with regard to this matter and are willing to assist you in evaluating our position with you.

Regards,

David R. Hall

David R. Hall
President
Novatek Inc.
2185 South Larsen Parkway
Provo, Utah 84606

Enclosures
cc: Gerry Flynn

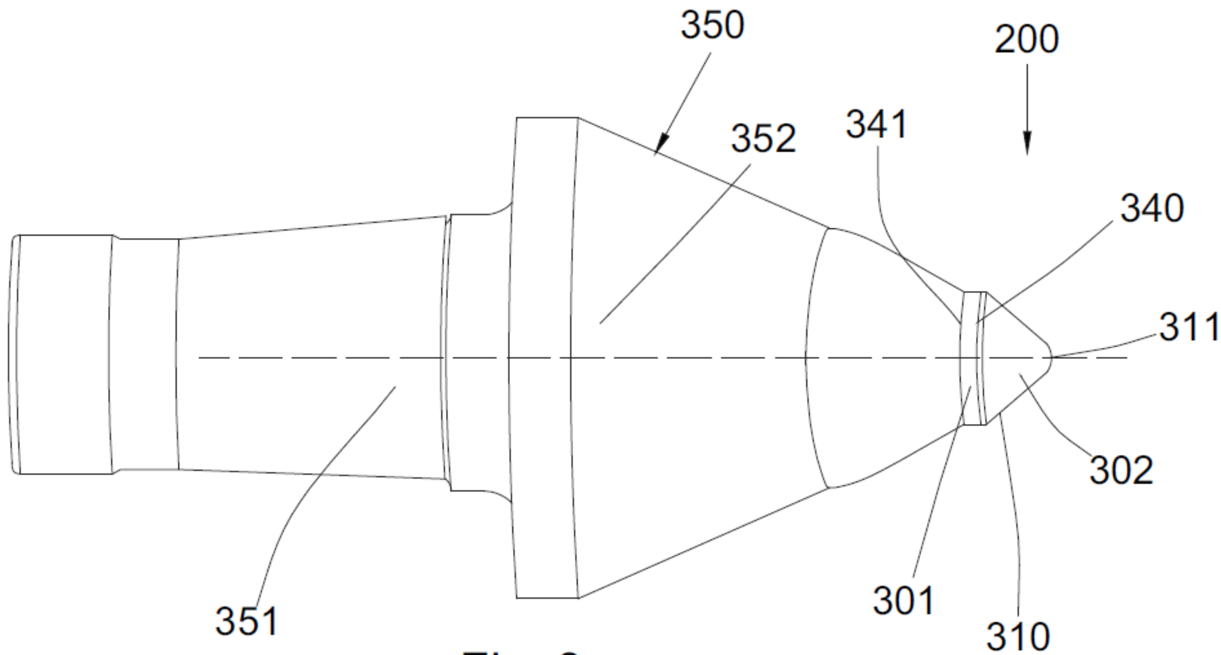

Fig. 3a

U.S. Patent No. 7,384,105

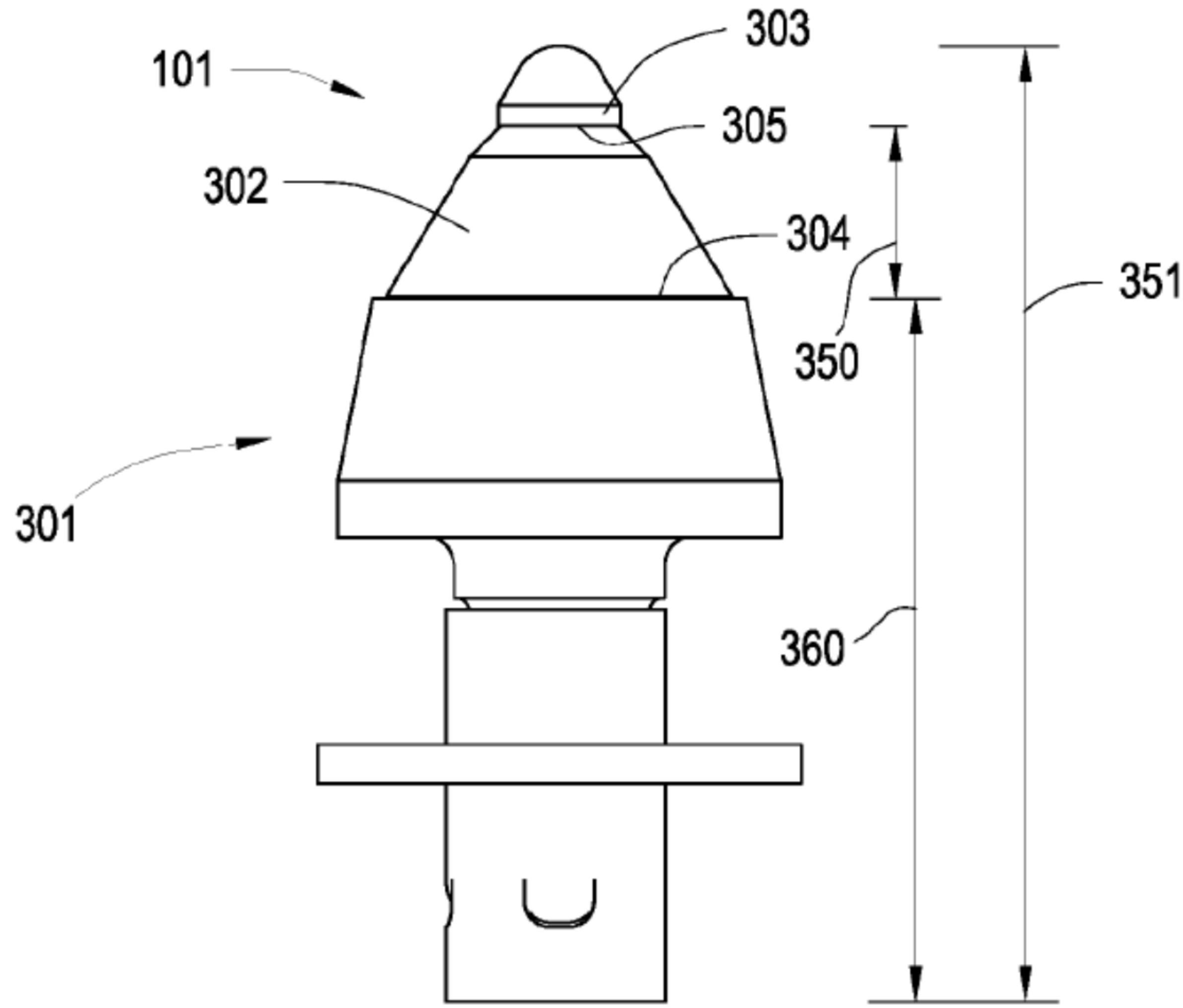

Fig. 3

U.S. Patent No. 7,665,552

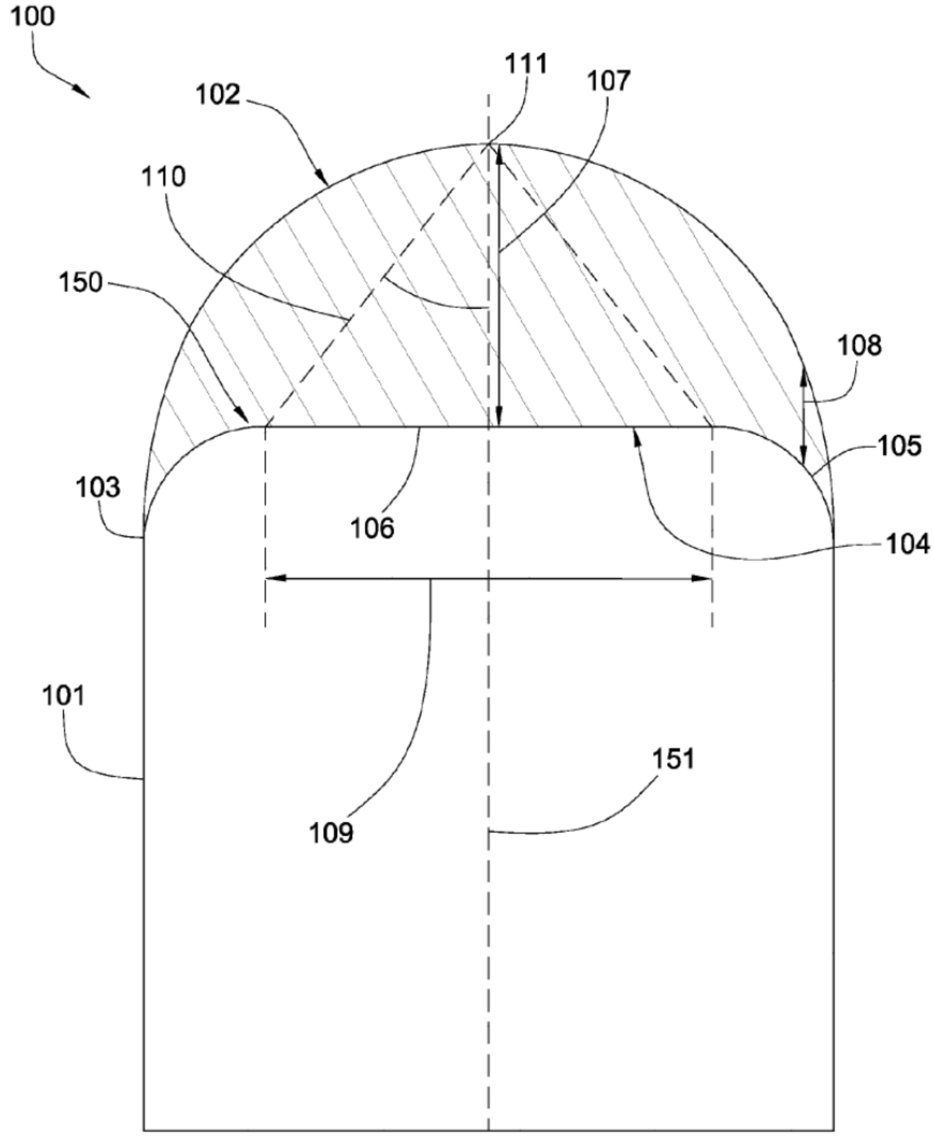

Fig. 1

U.S. Patent No. 7,353,893

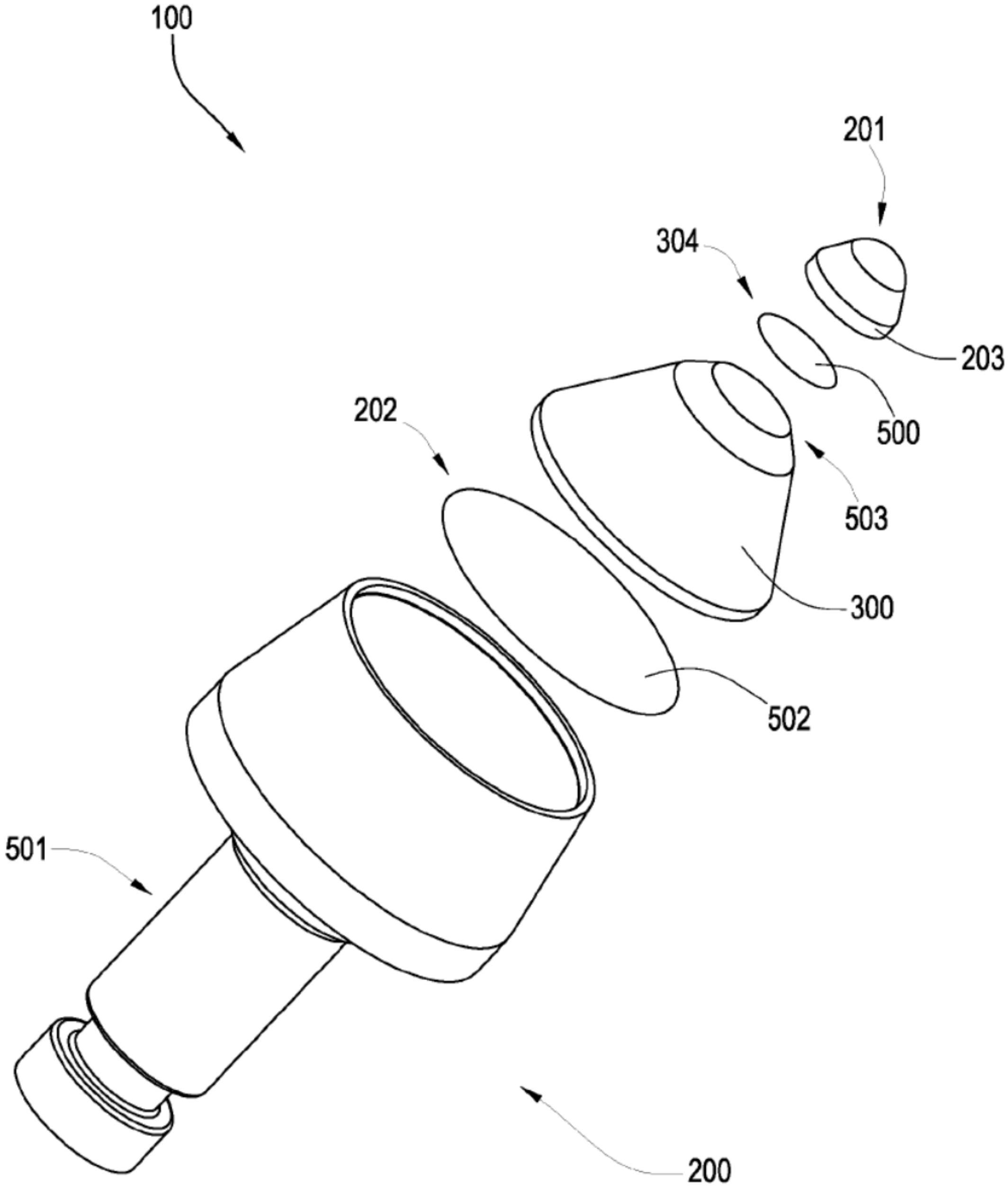

Fig. 5

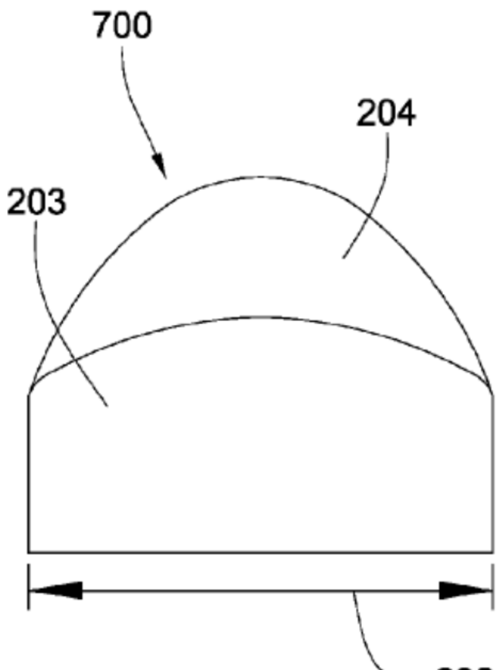

Fig. 6

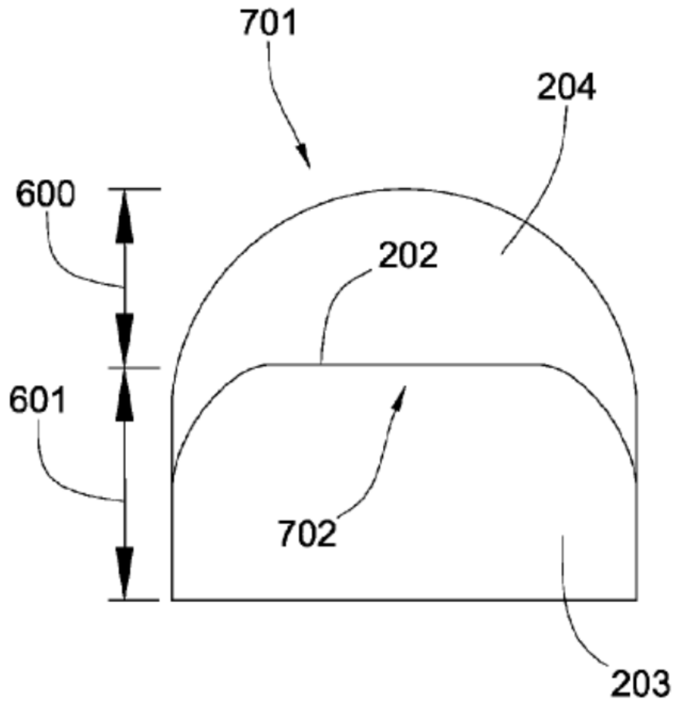

Fig. 7

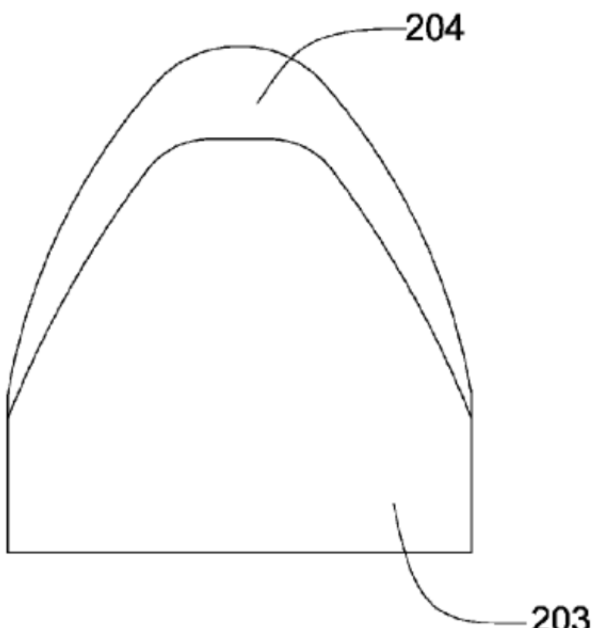

Fig. 8

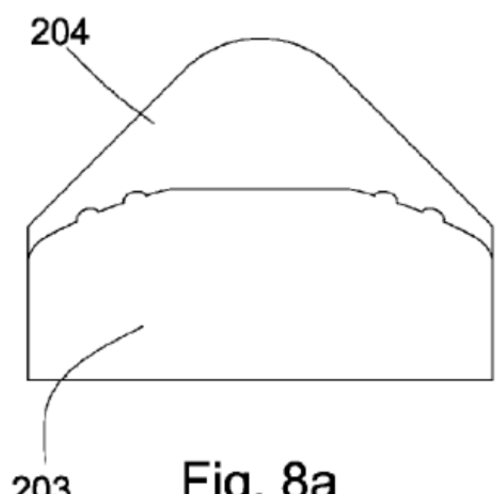

Fig. 8a

U.S. Patent No. 8,028,774

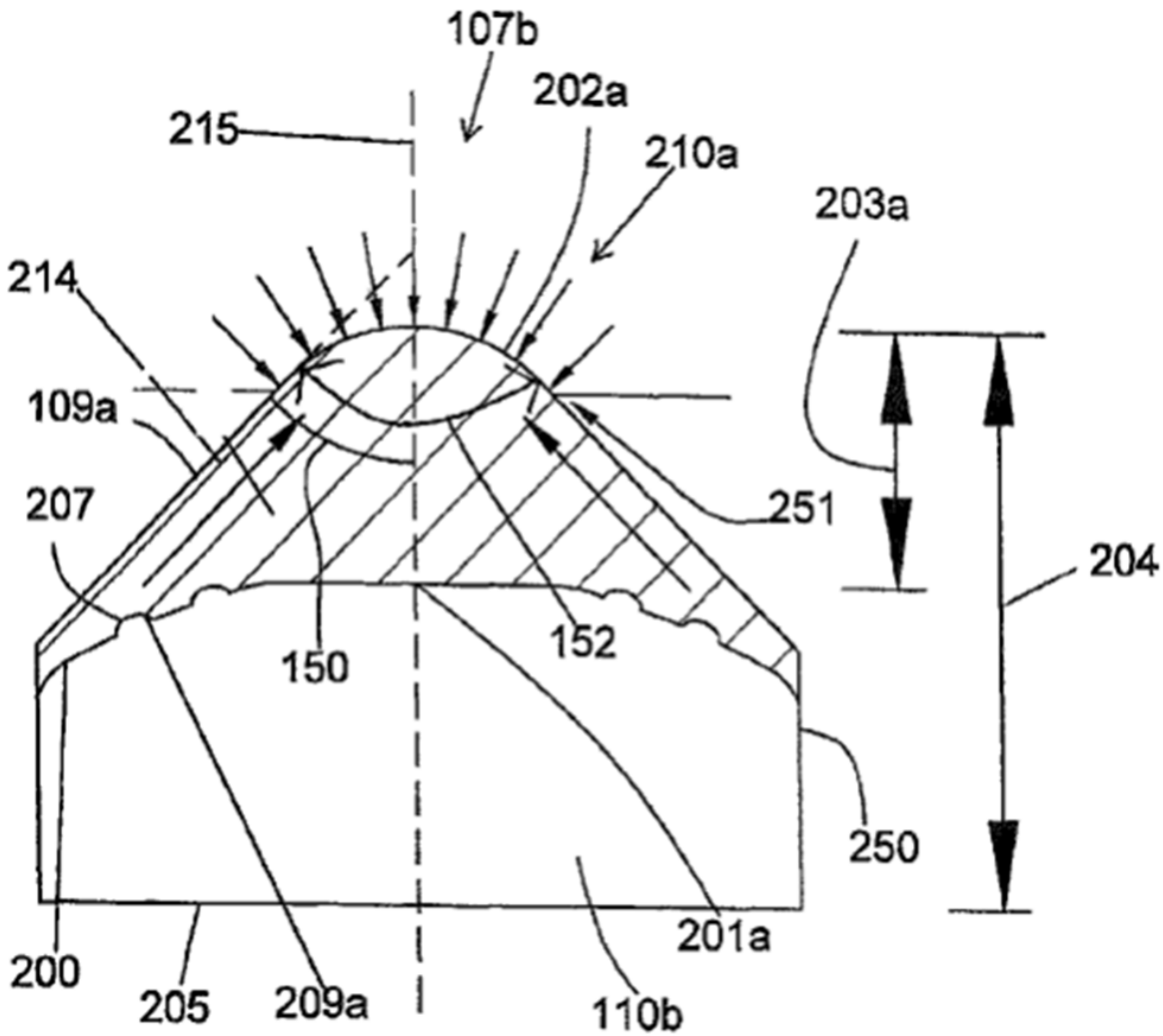

Fig. 2

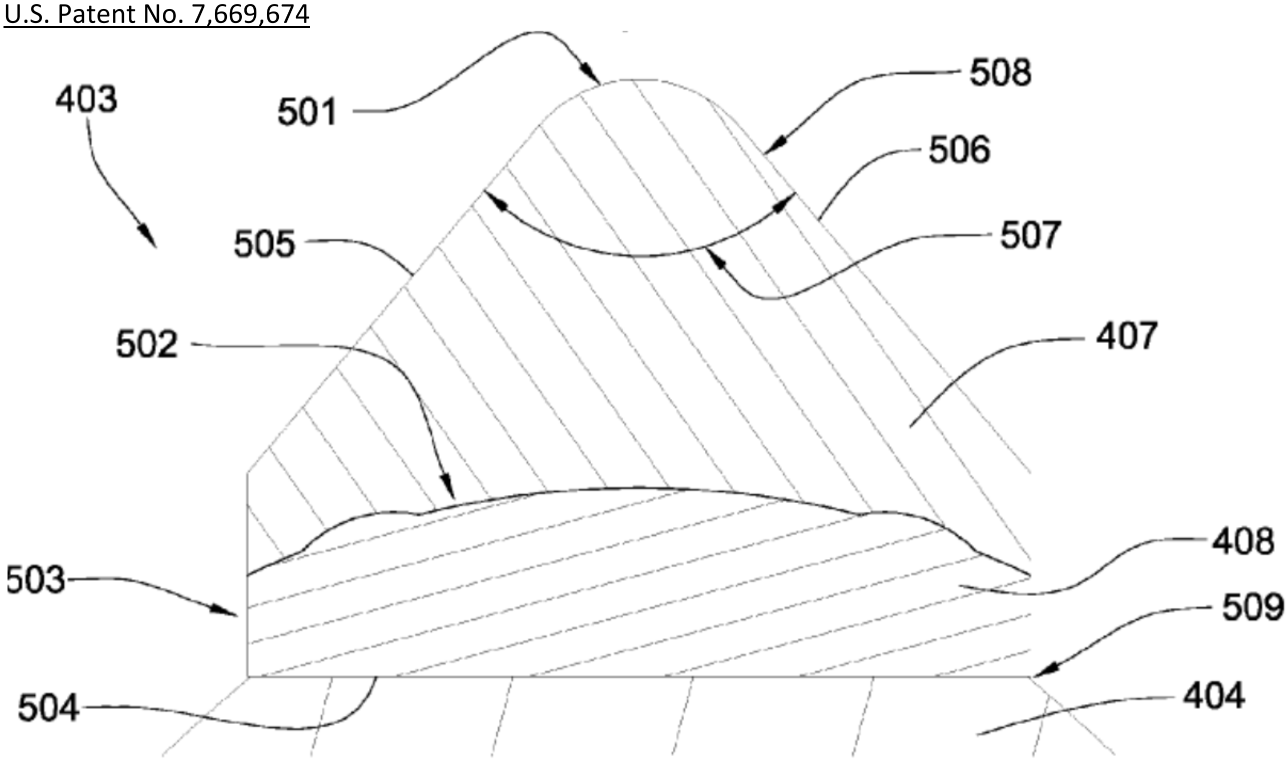

Fig. 5

EXHIBIT E

PATENT ASSIGNMENT

Electronic Version v1.1
Stylesheet Version v1.1

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
Mr. David R. Hall	01/22/2010

RECEIVING PARTY DATA

Name:	Schlumberger Technology Corporation
Street Address:	5599 San Felipe
Internal Address:	Suite 1600
City:	Houston
State/Country:	TEXAS
Postal Code:	77056

PROPERTY NUMBERS Total: 22

Property Type	Number
Patent Number:	7598886
Patent Number:	7503606
Patent Number:	7488194
Patent Number:	7469972
Patent Number:	7464993
Patent Number:	7384105
Patent Number:	7338135
Patent Number:	7419224
Patent Number:	7413256
Patent Number:	7445294
Patent Number:	7320505
Patent Number:	7410221
Patent Number:	7527105
Patent Number:	7353893

OP $880.00 7598886

Patent Number:	7469756
Patent Number:	7347292
Application Number:	11381709
Application Number:	11424806
Application Number:	11927917
Application Number:	11553338
Application Number:	11621183
Application Number:	11679727

CORRESPONDENCE DATA

Fax Number:	(713)651-5246

Correspondence will be sent via US Mail when the fax attempt is unsuccessful.

Phone:	7136513745
Email:	bcobb@fulbright.com
Correspondent Name:	James W. Repass
Address Line 1:	1301 McKinney Street
Address Line 2:	Fulbright & Jaworski L.L.P.
Address Line 4:	Houston, TEXAS 77010

ATTORNEY DOCKET NUMBER:	SCHLUMBERGER10911410
NAME OF SUBMITTER:	James W. Repass

Total Attachments: 14
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INTELLECTUAL PROPERTY ASSIGNMENT

This Intellectual Property Assignment (the "***Assignment***") is entered into as of January 22, 2010 ("***Effective Date***") by and between David R. Hall ("***Hall***" or "***Assignor***") and Schlumberger Technology Corporation, a Texas corporation ("***Assignee***"). Assignor and Assignee are referred to herein collectively as the "***Parties***" and each, individually, as a "***Party***."

WHEREAS, Assignor desires to sell, convey, assign, transfer and deliver to Assignee, and Assignee desires to purchase, acquire, and accept from Assignor, all of Assignor's right, title and interest in and to Assignor's intellectual property assets as set forth in Schedule A hereto (the "***Intellectual Property Assets***").

NOW, THEREFORE, for ten dollars ($10) and other good and sufficient consideration, receipt of which is hereby acknowledged, Assignor does hereby sell, assign, transfer and set over, unto Assignee, its successors, legal representatives and assigns, the entire right, title, and interest in and to the Intellectual Property Assets set forth in Schedule A hereof, which Assets include the following: (a) utility and design patents, utility and design patent applications, and to any and all direct and indirect divisions, continuations and continuations-in-part of said application, and any and all Letters Patent in the United States and all foreign countries which may be granted therefore and thereon, and reissues, reexaminations and extensions of said Letters Patent, and all rights under the International Convention for the Protection of Industrial Property; and (b) all other rights which Assignor has enjoyed thereunder both in the United States and throughout all countries of the world, including any and all rights of recovery based on infringement of said Intellectual Property Assets accruing after the Effective Date, the same to be held and enjoyed by Assignee, its successors, and assigns forever and to the full end of the terms for which any of the aforesaid Intellectual Property Assets are registered and any renewals of the terms thereof;

AND FOR THE SAME CONSIDERATION, Assignor also hereby covenants and agrees that, at the time of execution and delivery of these presents, Assignor is the sole and lawful owner of the entire right, title, and interest in and to the said registrations and applications and believes it is the sole and lawful owner of the entire right, title, and interest to said Intellectual Property Assets and said goodwill associated therewith and that the same are unencumbered and that Assignor has good and full right and lawful authority to sell and convey the same in the manner herein set forth;

AND FOR THE SAME CONSIDERATION, Assignor hereby covenants and agrees that the Assignor will, whenever counsel of the Assignee or the counsel of its successors, legal representatives, and assigns shall advise that it is lawful and desirable, sign all papers and documents, deliver necessary documents including original registration certificates, if available, take all lawful oaths, execute separate confirmatory assignments, and do all acts reasonably necessary or desirable to be done for the procurement, maintenance, enforcement, and defense of said Intellectual Property Assets and registrations thereof without charge to Assignee, its successors, legal representatives, and assigns, other than reasonable costs and expenses incurred by Assignor or any of its employees, agents, and representatives in connection with the foregoing actions.

[Signatures on following page]

IN WITNESS WHEREOF, the Parties have executed this Assignment on the date first written above.

David R. Hall
David R. Hall

SCHLUMBERGER TECHNOLOGY CORPORATION

By:
Name: RL LEDEBOER.
Title: ATTORNEY IN FACT

SIGNATURE PAGE TO
HALL IP ASSIGNMENT

SCHEDULE A

Ref. No.	Docket	Country	Status	Assignee (USPTO)	Title
5,396,965	85.0001	US	Expired	DAVID R. HALL	Down-hole Mud Actuated Hammer
10/633,889	85.0002-2	US	Abandoned	DAVID R. HALL	Pressurized Battery For High-Temperature, High-Pressure Environment
10/982,478	85.0005	US	Abandoned	DAVID R. HALL	Method for Distributing Electrical Power to Downhole Tools
10/931,864	85.0007	US	Abandoned	DAVID R. HALL	High-Speed, Downhole, Seismic Measurement System
6,390,181	85.0014	US	Granted	DAVID R. HALL	Densely Finned Tungsten Carbide and Polycrystalline Diamond Cooling Module
7380841	85.0021	US	Granted	DAVID R. HALL	High pressure connection
7586191	85.0025	US	Granted	DAVID R. HALL	Integrated circuit apparatus with heat spreader
7291028	85.0029	US	Granted	DAVID R. HALL	Actuated electric connection
7,482,945	85.0030-1	US	Granted	DAVID R. HALL	Apparatus for interfacing with a transmission path
7298286	85.0030	US	Granted	DAVID R. HALL	Apparatus for interfacing with a transmission path
7270199	85.0033	US	Granted	DAVID R. HALL	Cutting element with a non-shear stress relieving substrate interface
6733087	85.0037	US	8th-yr-fee due 11/15/2011	DAVID R. HALL	Pick for disintegrating natural and man-made materials
US06/043125	85.0045	PCT	Expired	DAVID R. HALL	Drill bit assembly
US07/64539	85.0051	PCT	Expired	DAVID R. HALL	
US06/43107	85.0053	PCT	Expired	DAVID R. HALL	
7350565	85.0060	US	Granted	DAVID R. HALL	Self-expandable cylinder in a downhole tool

11381709	85.0064	US	Pending	DAVID R. HALL	A Rigid Composite Structure with a Superhard Interior Surface
7598886	85.0067	US	Granted	DAVID R. HALL	System and method for wirelessly communicating with a downhole drill string
7503606	85.0073	US	Granted	DAVID R. HALL	Lifting assembly
7488194	85.0074	US	Granted	DAVID R. HALL	Downhole data and/or power transmission system
11424806	85.0076	US	Pending	DAVID R. HALL	An Attack Tool for Degrading Materials
7469972	85.0077	US	Granted	DAVID R. HALL	Wear Resistant Tool
7464993	85.0084	US	Granted	DAVID R. HALL	Attack tool
7384105	85.0085	US	Granted	DAVID R. HALL	Attack tool
7338135	85.0086	US	Granted	DAVID R. HALL	Holder for a degradation assembly
7419224	85.0087	US	Granted	DAVID R. HALL	Sleeve in a degradation assembly
7413256	85.0088	US	Granted	DAVID R. HALL	Washer for a degradation assembly
7445294	85.0089	US	Granted	DAVID R. HALL	Attack tool
11/927,917	85.0090-1	US	Pending	DAVID R. HALL	Shank for an Attack Tool
7320505	85.0090	US	Granted	DAVID R. HALL	Attack tool
7410221	85.0101	US	Granted	DAVID R. HALL	Retainer sleeve in a degradation assembly
11553338	85.0102	US	Pending	DAVID R. HALL	Superhard Insert with an Interface
7527105	85.0104	US	Granted	DAVID R. HALL	Power and/or data connection in a downhole component
11621183	85.0113	US	Pending	DAVID R. HALL	Tool String Direct Electrical Connection
7353893	85.0114	US	Granted	DAVID R. HALL	Tool with a large volume of a superhard material
7,469,756	85.0114-1	US	Granted	DAVID R. HALL	Tool with a large volume of a superhard material
7347292	85.0115	US	Granted	DAVID R. HALL	Braze material for an attack tool
11679727	85.0116	US	Pending	DAVID R. HALL	Method of Manufacturing Downhole Tool String Components

7873780.6	85.0125	EU	pending	DAVID R. HALL	Thick Pointed Superhard Material
11673634	85.0125	US	Pending	DAVID R. HALL	Thick Pointed Superhard Material
200780037792.8	85.0125	CN	pending	DAVID R. HALL	Thick Pointed Superhard Material
2009/00926	85.0125	ZA	pending	DAVID R. HALL	Thick Pointed Superhard Material
PCT/US07/75670	85.0125	PCT	expired	DAVID R. HALL	Thick Pointed Superhard Material
12/625,728	85.0125-1	US	pending	DAVID R. HALL	Thick Pointed Superhard Material
12/625,908	85.0125-2	US	pending	DAVID R. HALL	Thick Pointed Superhard Material
12/627,009	85.0125-3	US	pending	DAVID R. HALL	Thick Pointed Superhard Material
7568770	85.0132	US	Granted	DAVID R. HALL	Pick assembly
7404725	85.0134	US	Granted	DAVID R. HALL	Wiper for tool string direct electrical connection
7462051	85.0134-1	US	Granted	DAVID R. HALL	Wiper for tool string direct electrical connection
7396086	85.0138	US	Granted	DAVID R. HALL	Pick assembly
7588102	85.0139	US	Granted	DAVID R. HALL	High impact resistant tool
D554162	85.0140	US	Granted	DAVID R. HALL	Diamond enhanced cutting element
11734675	85.0141	US	Pending	DAVID R. HALL	High Impact Shearing Element
7401863	85.0142	US	Granted	DAVID R. HALL	Press-fit pick
7572134	85.0143	US	Granted	DAVID R. HALL	Centering assembly for an electric downhole connection
11749039	85.0145	US	Pending	DAVID R. HALL	Spring Loaded Pick
7469971	85.0147	US	Granted	DAVID R. HALL	Lubricated pick
7475948	85.0148	US	Granted	DAVID R. HALL	Pick with a bearing
11747341	85.0149	US	Pending	DAVID R. HALL	Diamond Nozzle
7594703	85.0150	US	Granted	DAVID R. HALL	Pick with a reentrant
11773561	85.0156	US	Pending	DAVID R. HALL	Energy Storage in an Elastic Vessel
12/556,488	85.0157-1	US	Pending	DAVID R. HALL	Externally guided and directed field induction resistivity tool
12/395,249	85.0159-1	US	Pending	DAVID R. HALL	Jack element with a stop-off
11761730	85.0161	US	Pending	DAVID R. HALL	Data and/or PowerSwivel

7571782	85.0163	US	Granted	DAVID R. HALL	Stiffened blade for shear-type drill bit
11766975	85.0167	US	Pending	DAVID R. HALL	Rotary Drag Bit with Pointed Cutting Elements
11828848	85.0169	US	Pending	DAVID R. HALL	Borehole Liner
11774227	85.0171	US	Pending	DAVID R. HALL	Carbide Stem Press Fit into a Steel Body of A Pick
11766903	85.0173	US	Pending	DAVID R. HALL	Attack Tool with an Interruption
11773271	85.0174	US	Pending	DAVID R. HALL	Tapered Bore in a Pick
11829577	85.0179	US	Pending	DAVID R. HALL	Pointed Diamond Working Ends on a Shear Bit
11829761	85.0183	US	Pending	DAVID R. HALL	Pick Shank in Axial Tension
7455117	85.0185	US	Granted	DAVID R. HALL	Downhole winding tool
11844662	85.0188	US	Pending	DAVID R. HALL	Pick Assembly
7600823	85.0194	US	Granted	DAVID R. HALL	Pick assembly
D556137	85.0195	US	Granted	DAVID R. HALL	Pick Bolster
D581952	85.0196	US	Granted	DAVID R. HALL	Pick
11851582	85.0198	US	Pending	DAVID R. HALL	Pick with Carbide Cap
12/559,731	85.0199-1	US	Pending	DAVID R. HALL	Indenting Member for a Drill Bit
11861641	85.0202	US	Pending	DAVID R. HALL	Downhole Drill Bit
11871722	85.0205	US	Pending	DAVID R. HALL	Hollow Pick Shank
11871835	85.0208	US	Pending	DAVID R. HALL	Non-rotating Pick with a Pressed in Carbide Segment
7413258	85.0209	US	Granted	DAVID R. HALL	Hollow pick shank
11928471	85.0211	US	Pending	DAVID R. HALL	Tool Holder Sleeve
11947644	85.0215	US	Pending	DAVID R. HALL	Shank Assembly
11953424	85.0220	US	Pending	DAVID R. HALL	Holder Assembly
11971965	85.0222	US	Pending	DAVID R. HALL	Pick with an Interlocked Bolster
11962497	85.0223	US	Pending	DAVID R. HALL	Retention for Holder Shank
12020924	85.0227	US	Pending	DAVID R. HALL	Shank Assembly with a Tensioned Element
12021019	85.0229	US	Pending	DAVID R. HALL	Impact Tool
12021051	85.0232	US	Pending	DAVID R. HALL	Impact Tool
29304177	85.0238	US	Pending	DAVID R. HALL	Drill Bit
12051586	85.0245	US	Pending	DAVID R. HALL	Degradation Assembly
12041880	85.0247	US	Pending	DAVID R. HALL	Attack Tool
12051689	85.0249	US	Pending	DAVID R. HALL	Degradation

					Assembly
12051738	85.0250	US	Pending	DAVID R. HALL	Degradation Assembly
12099038	85.0252	US	Pending	DAVID R. HALL	Method of Forming a Workpiece
12057597	85.0253	US	Pending	DAVID R. HALL	Drill Bit
12112743	85.0256	US	Pending	DAVID R. HALL	Locking fixture for a degradation assembly
12112099	85.0259	US	Pending	DAVID R. HALL	Layered polycrystalline diamond
12112815	85.0270	US	Pending	DAVID R. HALL	Locking fixture
12178467	85.0272	US	Pending	DAVID R. HALL	Drill Bit Porting System
12135595	85.0273	US	Pending	DAVID R. HALL	Retention System
12135654	85.0275	US	Pending	DAVID R. HALL	Retention System
12135714	85.0276	US	Pending	DAVID R. HALL	Retention System
12146665	85.0277	US	Pending	DAVID R. HALL	High-impact Resistant Tool
US08/69231	85.0279	PCT	expired	DAVID R. HALL	Wear Resistant Tool
7533738	85.0280	US	Granted	DAVID R. HALL	Insert in a downhole drill bit
12169345	85.0281	US	Pending	DAVID R. HALL	Retention for an Insert
12177556	85.0282	US	Pending	DAVID R. HALL	Degradation assembly shield
12177599	85.0283	US	Pending	DAVID R. HALL	Shield of a Degradation Assembly
12177637	85.0284	US	Pending	DAVID R. HALL	Degradation Assembly Shield
7628233	85.0285	US	Granted	DAVID R. HALL	Carbide Bolster
12200786	85.0286	US	Pending	DAVID R. HALL	Braze Thickness Control
12200810	85.0287	US	Pending	DAVID R. HALL	Braze Thickness Control
12366706	85.0308	US	Pending	DAVID R. HALL	Thermally Stable Pointed Diamond with Increased Impact Resistance
12372302	85.0309	US	Pending	DAVID R. HALL	Chamfered Pointed Enhanced Diamond Insert
12390353	85.0311	US	Pending	DAVID R. HALL	Inductive Power Coupler
61/164,770	85.0319	US	Pending	DAVID R. HALL	TSP Segments Integrated into a Cutting Element
12/424,815	85.0321	US	Pending	DAVID R. HALL	Seal with Rigid Element for Degradation

					Assembly
12428531	85.0324	US	Pending	DAVID R. HALL	Manually Rotatable Tool
12428541	85.0325	US	Pending	DAVID R. HALL	Manually Rotatable Tool
12/491,848	85.0331	US	Pending	DAVID R. HALL	Resilient Pick Shank
12491897	85.0332	US	Pending	DAVID R. HALL	Resilient Pick Shank
12492804	85.0333	US	Pending	DAVID R. HALL	Bonded Assembly having Low Residual Stress
12493013	85.0334	US	Pending	DAVID R. HALL	Dense Diamond Body
12494802	85.0335	US	Pending	DAVID R. HALL	Downhole Lubrication System
12494888	85.0336	US	Pending	DAVID R. HALL	Downhole Lubrication System
12/614,614	85.0349	US	Pending	DAVID R. HALL	Test Fixture that Positions a Cutting Element at a Positive Rake Angle
12/619,305	85.0350	US	Pending	DAVID R. HALL	A Cutting Element Attached to a Downhole Fixed Bladed Bit at a Positive Rake
12/616,377	85.0352	US	Pending	DAVID R. HALL	A Fixed Bladed Bit that Shifts Weight between an Indentor and Cutting Elements
12/619,423	85.0353	US	Pending	DAVID R. HALL	Method for Drilling with a Fixed Bladed Bit
12/619,466	85.0354	US	Pending	DAVID R. HALL	Cutting Element with Low Metal Concentration
12536695	85.0250-1	US	Pending	DAVID R. HALL	Degradation Assembly
Ref. No.	**Docket**	**Country**	**Status**	**Assignee (USPTO)**	**Title**
5,396,965	85.0001	US	Expired	DAVID R. HALL	Down-hole Mud Actuated Hammer
10/633,889	85.0002-2	US	Abandoned	DAVID R. HALL	Pressurized Battery For High-Temperature, High-Pressure Environment
10/982,478	85.0005	US	Abandoned	DAVID R. HALL	Method for Distributing Electrical Power to Downhole Tools
10/931,864	85.0007	US	Abandoned	DAVID R. HALL	High-Speed,

					Downhole, Seismic Measurement System
6,390,181	85.0014	US	Granted	DAVID R. HALL	Densely Finned Tungsten Carbide and Polycrystalline Diamond Cooling Module
7380841	85.0021	US	Granted	DAVID R. HALL	High pressure connection
7586191	85.0025	US	Granted	DAVID R. HALL	Integrated circuit apparatus with heat spreader
7291028	85.0029	US	Granted	DAVID R. HALL	Actuated electric connection
7,482,945	85.0030-1	US	Granted	DAVID R. HALL	Apparatus for interfacing with a transmission path
7298286	85.0030	US	Granted	DAVID R. HALL	Apparatus for interfacing with a transmission path
7270199	85.0033	US	Granted	DAVID R. HALL	Cutting element with a non-shear stress relieving substrate interface
6733087	85.0037	US	8th-yr-fee due 11/15/2011	DAVID R. HALL	Pick for disintegrating natural and man-made materials
US06/043125	85.0045	PCT	Expired	DAVID R. HALL	Drill bit assembly
US07/64539	85.0051	PCT	Expired	DAVID R. HALL	
US06/43107	85.0053	PCT	Expired	DAVID R. HALL	
7350565	85.0060	US	Granted	DAVID R. HALL	Self-expandable cylinder in a downhole tool
11381709	85.0064	US	Pending	DAVID R. HALL	A Rigid Composite Structure with a Superhard Interior Surface
7598886	85.0067	US	Granted	DAVID R. HALL	System and method for wirelessly communicating with a downhole drill string
7503606	85.0073	US	Granted	DAVID R. HALL	Lifting assembly
7488194	85.0074	US	Granted	DAVID R. HALL	Downhole data and/or power transmission system
11424806	85.0076	US	Pending	DAVID R. HALL	An Attack Tool for Degrading Materials
7469972	85.0077	US	Granted	DAVID R. HALL	Wear Resistant Tool
7464993	85.0084	US	Granted	DAVID R. HALL	Attack tool
7384105	85.0085	US	Granted	DAVID R. HALL	Attack tool
7338135	85.0086	US	Granted	DAVID R. HALL	Holder for a degradation assembly

7419224	85.0087	US	Granted	DAVID R. HALL	Sleeve in a degradation assembly
7413256	85.0088	US	Granted	DAVID R. HALL	Washer for a degradation assembly
7445294	85.0089	US	Granted	DAVID R. HALL	Attack tool
11/927,917	85.0090-1	US	Pending	DAVID R. HALL	Shank for an Attack Tool
7320505	85.0090	US	Granted	DAVID R. HALL	Attack tool
7410221	85.0101	US	Granted	DAVID R. HALL	Retainer sleeve in a degradation assembly
11553338	85.0102	US	Pending	DAVID R. HALL	Superhard Insert with an Interface
7527105	85.0104	US	Granted	DAVID R. HALL	Power and/or data connection in a downhole component
11621183	85.0113	US	Pending	DAVID R. HALL	Tool String Direct Electrical Connection
7353893	85.0114	US	Granted	DAVID R. HALL	Tool with a large volume of a superhard material
7,469,756	85.0114-1	US	Granted	DAVID R. HALL	Tool with a large volume of a superhard material
7347292	85.0115	US	Granted	DAVID R. HALL	Braze material for an attack tool
11679727	85.0116	US	Pending	DAVID R. HALL	Method of Manufacturing Downhole Tool String Components
7873780.6	85.0125	EU	pending	DAVID R. HALL	Thick Pointed Superhard Material
11673634	85.0125	US	Pending	DAVID R. HALL	Thick Pointed Superhard Material
200780037792.8	85.0125	CN	pending	DAVID R. HALL	Thick Pointed Superhard Material
2009/00926	85.0125	ZA	pending	DAVID R. HALL	Thick Pointed Superhard Material
PCT/US07/75670	85.0125	PCT	expired	DAVID R. HALL	Thick Pointed Superhard Material
12/625,728	85.0125-1	US	pending	DAVID R. HALL	Thick Pointed Superhard Material
12/625,908	85.0125-2	US	pending	DAVID R. HALL	Thick Pointed Superhard Material
12/627,009	85.0125-3	US	pending	DAVID R. HALL	Thick Pointed Superhard Material
7568770	85.0132	US	Granted	DAVID R. HALL	Pick assembly
7404725	85.0134	US	Granted	DAVID R. HALL	Wiper for tool string direct electrical connection
7462051	85.0134-1	US	Granted	DAVID R. HALL	Wiper for tool string direct electrical connection

7396086	85.0138	US	Granted	DAVID R. HALL	Pick assembly
7588102	85.0139	US	Granted	DAVID R. HALL	High impact resistant tool
D554162	85.0140	US	Granted	DAVID R. HALL	Diamond enhanced cutting element
11734675	85.0141	US	Pending	DAVID R. HALL	High Impact Shearing Element
7401863	85.0142	US	Granted	DAVID R. HALL	Press-fit pick
7572134	85.0143	US	Granted	DAVID R. HALL	Centering assembly for an electric downhole connection
11749039	85.0145	US	Pending	DAVID R. HALL	Spring Loaded Pick
7469971	85.0147	US	Granted	DAVID R. HALL	Lubricated pick
7475948	85.0148	US	Granted	DAVID R. HALL	Pick with a bearing
11747341	85.0149	US	Pending	DAVID R. HALL	Diamond Nozzle
7594703	85.0150	US	Granted	DAVID R. HALL	Pick with a reentrant
11773561	85.0156	US	Pending	DAVID R. HALL	Energy Storage in an Elastic Vessel
12/556,488	85.0157-1	US	Pending	DAVID R. HALL	Externally guided and directed field induction resistivity tool
12/395,249	85.0159-1	US	Pending	DAVID R. HALL	Jack element with a stop-off
11761730	85.0161	US	Pending	DAVID R. HALL	Data and/or PowerSwivel
7571782	85.0163	US	Granted	DAVID R. HALL	Stiffened blade for shear-type drill bit
11766975	85.0167	US	Pending	DAVID R. HALL	Rotary Drag Bit with Pointed Cutting Elements
11828848	85.0169	US	Pending	DAVID R. HALL	Borehole Liner
11774227	85.0171	US	Pending	DAVID R. HALL	Carbide Stem Press Fit into a Steel Body of A Pick
11766903	85.0173	US	Pending	DAVID R. HALL	Attack Tool with an Interruption
11773271	85.0174	US	Pending	DAVID R. HALL	Tapered Bore in a Pick
11829577	85.0179	US	Pending	DAVID R. HALL	Pointed Diamond Working Ends on a Shear Bit
11829761	85.0183	US	Pending	DAVID R. HALL	Pick Shank in Axial Tension
7455117	85.0185	US	Granted	DAVID R. HALL	Downhole winding tool
11844662	85.0188	US	Pending	DAVID R. HALL	Pick Assembly
7600823	85.0194	US	Granted	DAVID R. HALL	Pick assembly
D556137	85.0195	US	Granted	DAVID R. HALL	Pick Bolster
D581952	85.0196	US	Granted	DAVID R. HALL	Pick
11851582	85.0198	US	Pending	DAVID R. HALL	Pick with Carbide Cap
12/559,731	85.0199-1	US	Pending	DAVID R. HALL	Indenting Member for

					a Drill Bit
11861641	85.0202	US	Pending	DAVID R. HALL	Downhole Drill Bit
11871722	85.0205	US	Pending	DAVID R. HALL	Hollow Pick Shank
11871835	85.0208	US	Pending	DAVID R. HALL	Non-rotating Pick with a Pressed in Carbide Segment
7413258	85.0209	US	Granted	DAVID R. HALL	Hollow pick shank
11928471	85.0211	US	Pending	DAVID R. HALL	Tool Holder Sleeve
11947644	85.0215	US	Pending	DAVID R. HALL	Shank Assembly
11953424	85.0220	US	Pending	DAVID R. HALL	Holder Assembly
11971965	85.0222	US	Pending	DAVID R. HALL	Pick with an Interlocked Bolster
11962497	85.0223	US	Pending	DAVID R. HALL	Retention for Holder Shank
12020924	85.0227	US	Pending	DAVID R. HALL	Shank Assembly with a Tensioned Element
12021019	85.0229	US	Pending	DAVID R. HALL	Impact Tool
12021051	85.0232	US	Pending	DAVID R. HALL	Impact Tool
29304177	85.0238	US	Pending	DAVID R. HALL	Drill Bit
12051586	85.0245	US	Pending	DAVID R. HALL	Degradation Assembly
12041880	85.0247	US	Pending	DAVID R. HALL	Attack Tool
12051689	85.0249	US	Pending	DAVID R. HALL	Degradation Assembly
12051738	85.0250	US	Pending	DAVID R. HALL	Degradation Assembly
12099038	85.0252	US	Pending	DAVID R. HALL	Method of Forming a Workpiece
12057597	85.0253	US	Pending	DAVID R. HALL	Drill Bit
12112743	85.0256	US	Pending	DAVID R. HALL	Locking fixture for a degradation assembly
12112099	85.0259	US	Pending	DAVID R. HALL	Layered polycrystalline diamond
12112815	85.0270	US	Pending	DAVID R. HALL	Locking fixture
12178467	85.0272	US	Pending	DAVID R. HALL	Drill Bit Porting System
12135595	85.0273	US	Pending	DAVID R. HALL	Retention System
12135654	85.0275	US	Pending	DAVID R. HALL	Retention System
12135714	85.0276	US	Pending	DAVID R. HALL	Retention System
12146665	85.0277	US	Pending	DAVID R. HALL	High-impact Resistant Tool
US08/69231	85.0279	PCT	expired	DAVID R. HALL	Wear Resistant Tool
7533738	85.0280	US	Granted	DAVID R. HALL	Insert in a downhole drill bit
12169345	85.0281	US	Pending	DAVID R. HALL	Retention for an Insert
12177556	85.0282	US	Pending	DAVID R. HALL	Degradation assembly shield
12177599	85.0283	US	Pending	DAVID R. HALL	Shield of a Degradation Assembly

12177637	85.0284	US	Pending	DAVID R. HALL	Degradation Assembly Shield
7628233	85.0285	US	Granted	DAVID R. HALL	Carbide Bolster
12200786	85.0286	US	Pending	DAVID R. HALL	Braze Thickness Control
12200810	85.0287	US	Pending	DAVID R. HALL	Braze Thickness Control
12366706	85.0308	US	Pending	DAVID R. HALL	Thermally Stable Pointed Diamond with Increased Impact Resistance
12372302	85.0309	US	Pending	DAVID R. HALL	Chamfered Pointed Enhanced Diamond Insert
12390353	85.0311	US	Pending	DAVID R. HALL	Inductive Power Coupler
61/164,770	85.0319	US	Pending	DAVID R. HALL	TSP Segments Integrated into a Cutting Element
12/424,815	85.0321	US	Pending	DAVID R. HALL	Seal with Rigid Element for Degradation Assembly
12428531	85.0324	US	Pending	DAVID R. HALL	Manually Rotatable Tool
12428541	85.0325	US	Pending	DAVID R. HALL	Manually Rotatable Tool
12/491,848	85.0331	US	Pending	DAVID R. HALL	Resilient Pick Shank
12491897	85.0332	US	Pending	DAVID R. HALL	Resilient Pick Shank
12492804	85.0333	US	Pending	DAVID R. HALL	Bonded Assembly having Low Residual Stress
12493013	85.0334	US	Pending	DAVID R. HALL	Dense Diamond Body
12494802	85.0335	US	Pending	DAVID R. HALL	Downhole Lubrication System
12494888	85.0336	US	Pending	DAVID R. HALL	Downhole Lubrication System
12/614,614	85.0349	US	Pending	DAVID R. HALL	Test Fixture that Positions a Cutting Element at a Positive Rake Angle
12/619,305	85.0350	US	Pending	DAVID R. HALL	A Cutting Element Attached to a Downhole Fixed Bladed Bit at a Positive Rake
12/616,377	85.0352	US	Pending	DAVID R. HALL	A Fixed Bladed Bit that Shifts Weight between an Indentor and Cutting Elements
12/619,423	85.0353	US	Pending	DAVID R. HALL	Method for Drilling with a Fixed Bladed Bit
12/619,466	85.0354	US	Pending	DAVID R. HALL	Cutting Element with

					Low Metal Concentration
12536695	85.0250-1	US	Pending	DAVID R. HALL	Degradation Assembly

EXHIBIT F

US007384105B2

(12) United States Patent
Hall et al.

(10) Patent No.: US 7,384,105 B2

(45) Date of Patent: Jun. 10, 2008

(54) **ATTACK TOOL**

(76) Inventors: **David R. Hall**, 2185 S. Larsen Pkwy., Provo, UT (US) 84606; **Ronald Crockett**, 2185 S. Larson Pkwy., Provo, UT (US) 84606; **Jeff Jepson**, 2185 S. Larson Pkwy., Provo, UT (US) 84606

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/463,998**

(22) Filed: **Aug. 11, 2006**

(65) **Prior Publication Data**

US 2008/0036273 A1 Feb. 14, 2008

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/463,990, filed on Aug. 11, 2006, now Pat. No. 7,320,505, which is a continuation-in-part of application No. 11/463,975, filed on Aug. 11, 2006, which is a continuation-in-part of application No. 11/463,962, filed on Aug. 11, 2006.

(51) **Int. Cl.**
E21C 35/19 (2006.01)

(52) **U.S. Cl.** **299/111**; 299/113

(58) **Field of Classification Search** 299/111, 299/113

See application file for complete search history.

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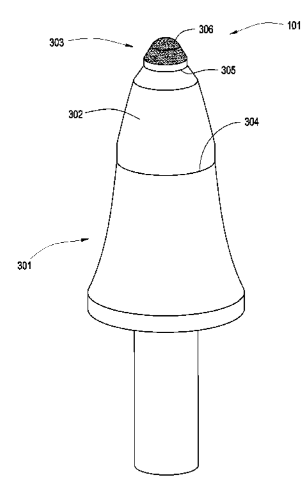
Primary Examiner—John Kreck
(74) *Attorney, Agent, or Firm*—Tyson J. Wilde

(57) **ABSTRACT**

In one aspect of the invention, an attack tool is disclosed which has a wear-resistant base suitable for attachment to a driving mechanism, a first cemented metal carbide segment brazed to the base at a first interface, and a second metal carbide segment brazed to the first carbide segment at a second interface opposite the base. The attack tool also having a braze material disposed in the second interface with 30 to 62 weight percent of palladium.

19 Claims, 17 Drawing Sheets



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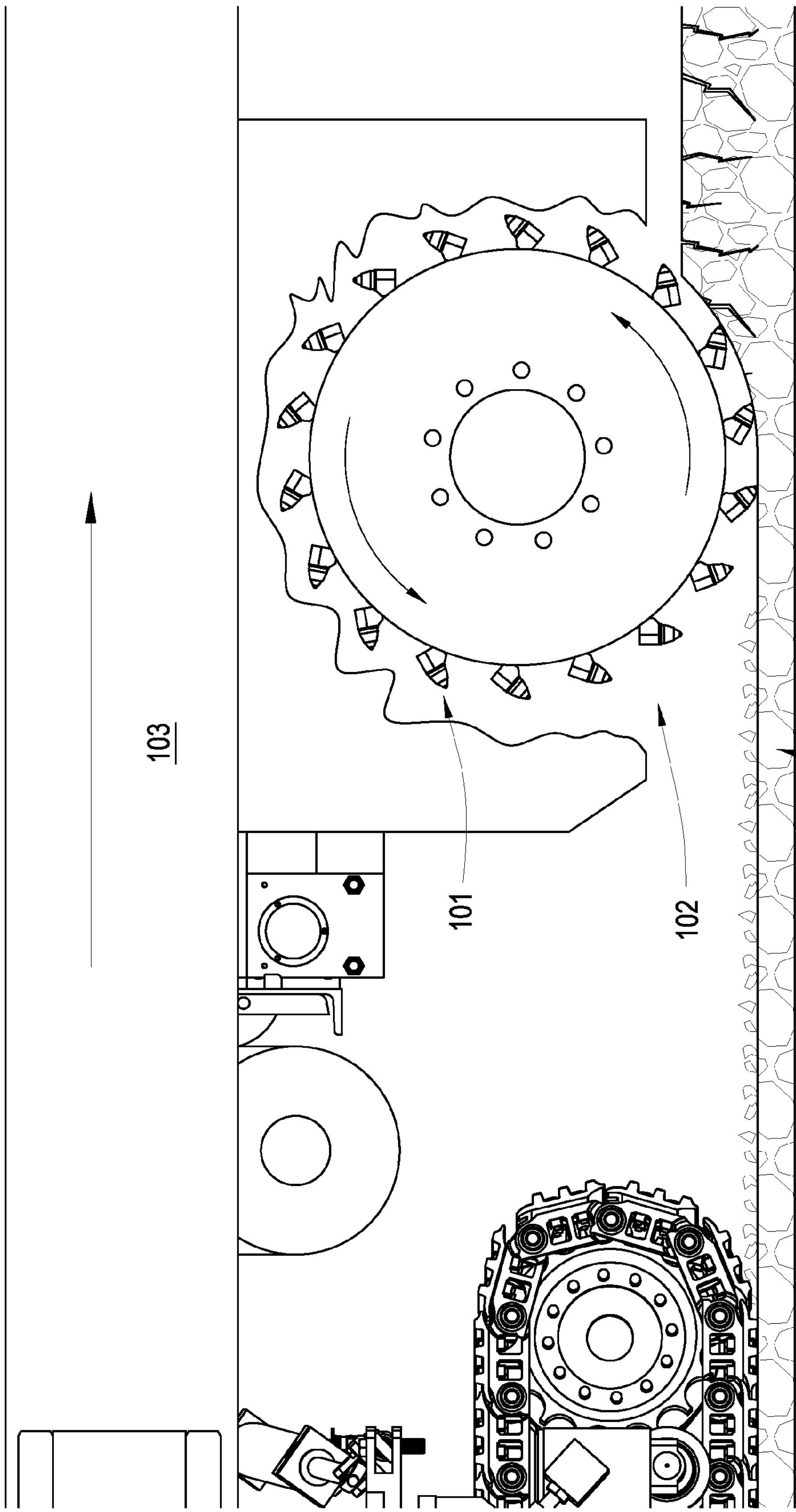

Fig. 1

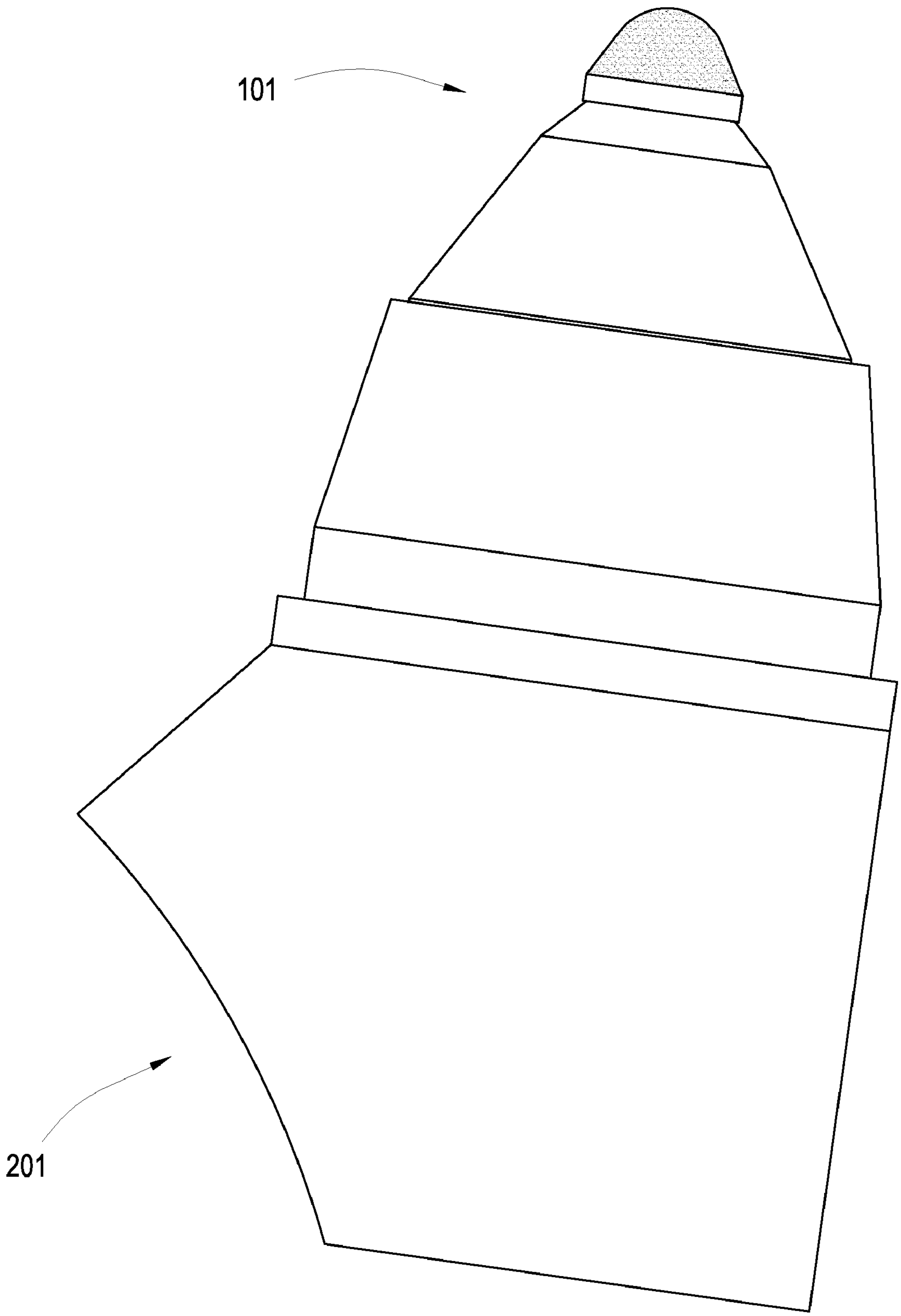

Fig. 2

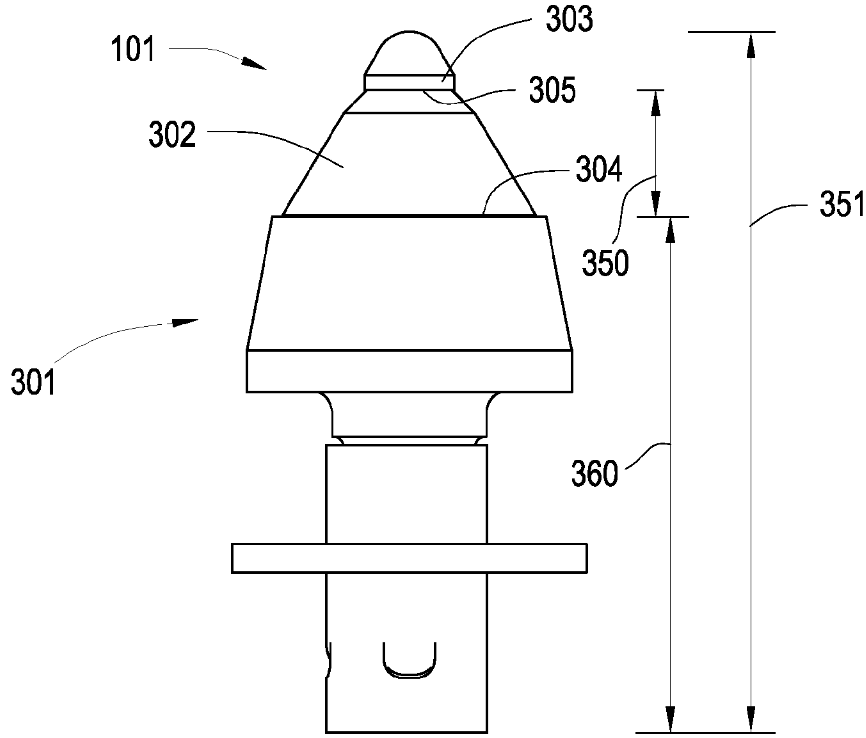
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Fig. 3

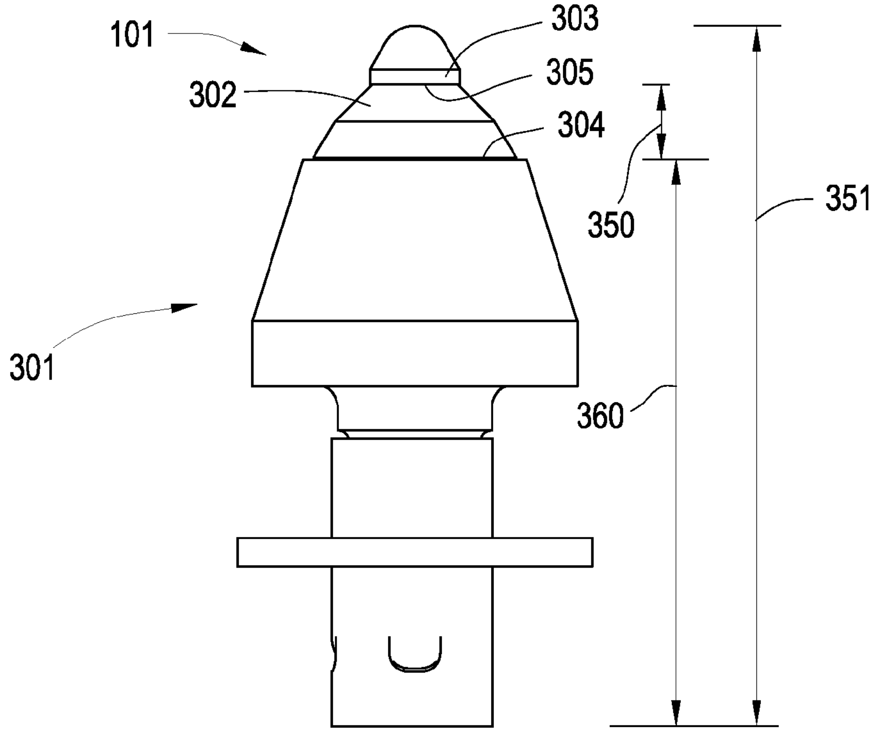
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Fig. 4

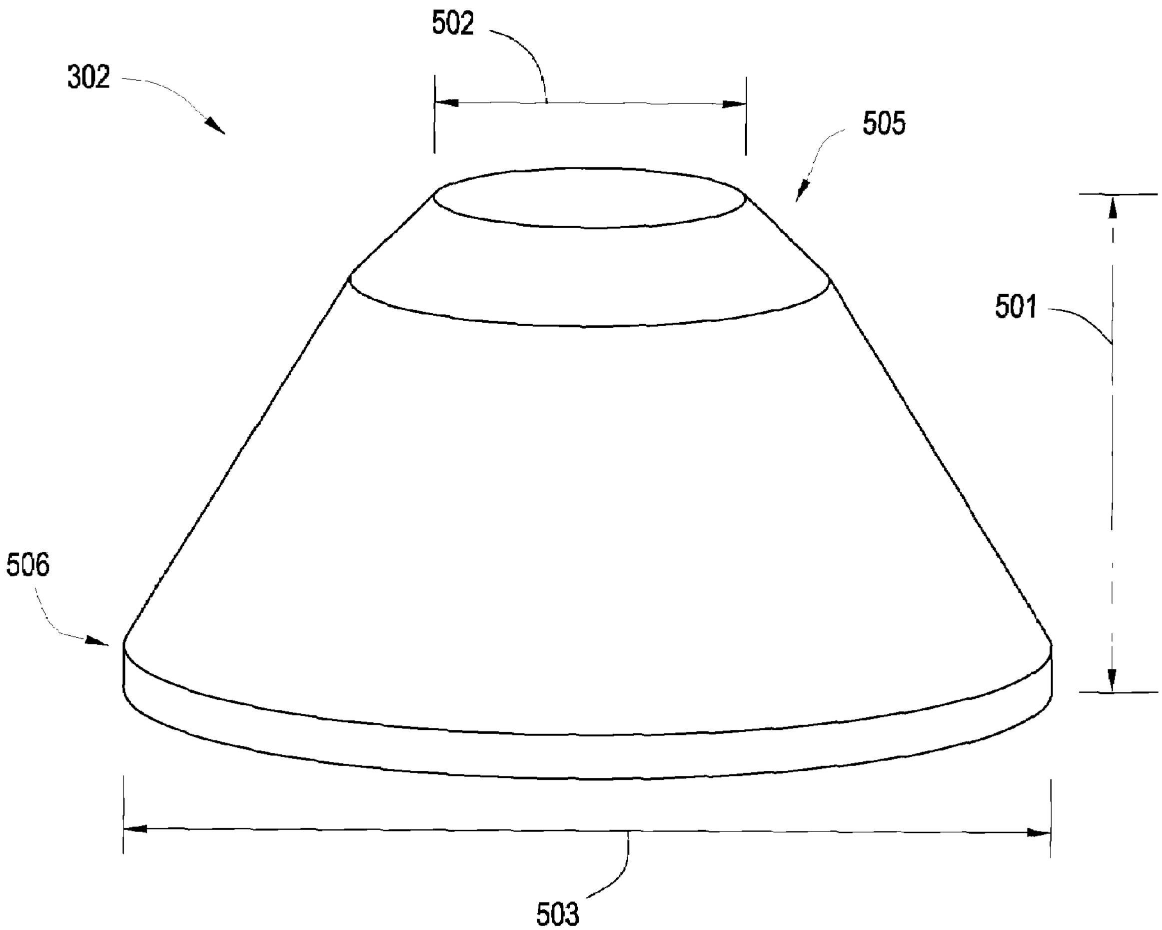

Fig. 5

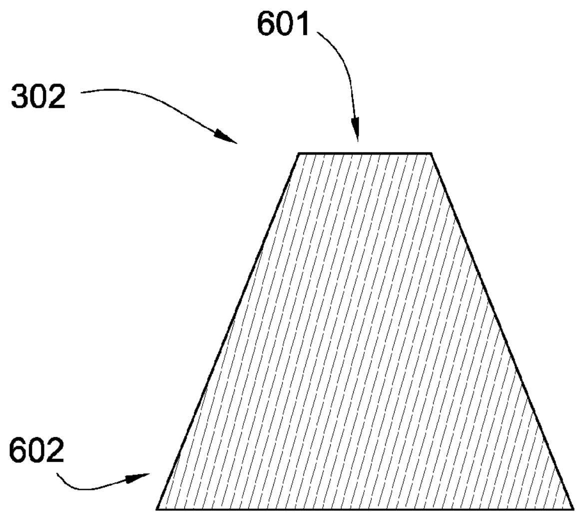

Fig. 6

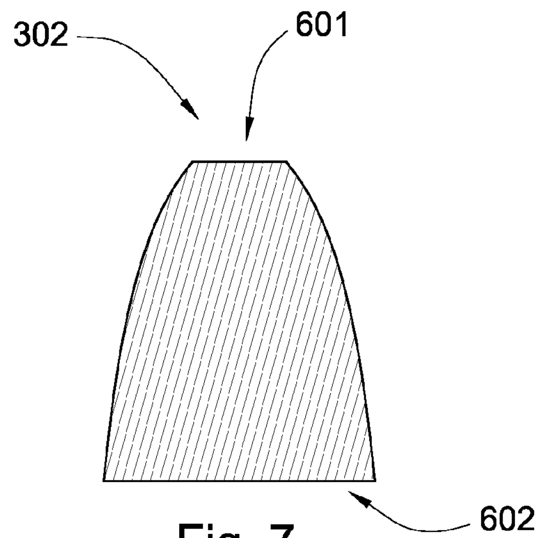

Fig. 7

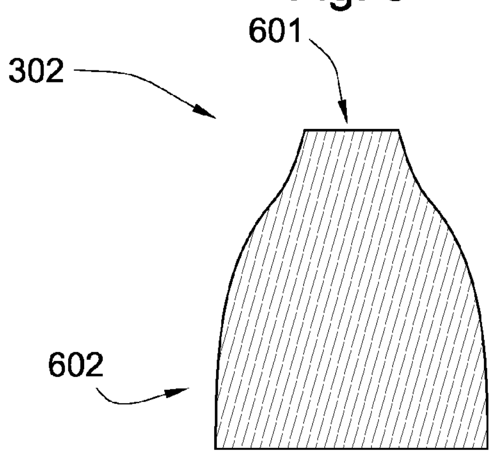

Fig. 8

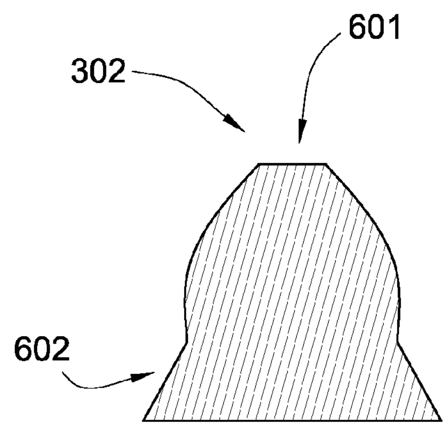

Fig. 9

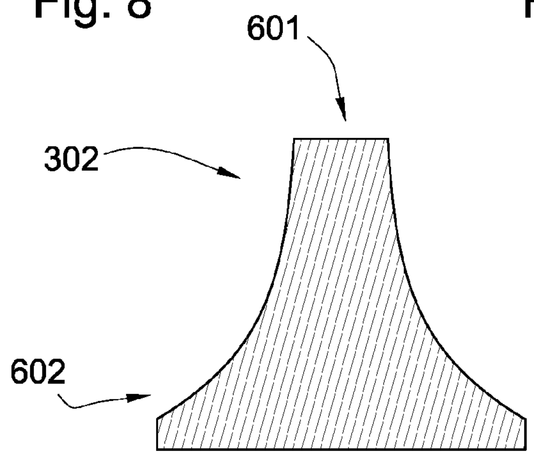

Fig. 10

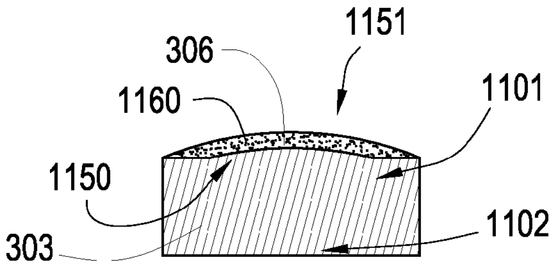

Fig. 11

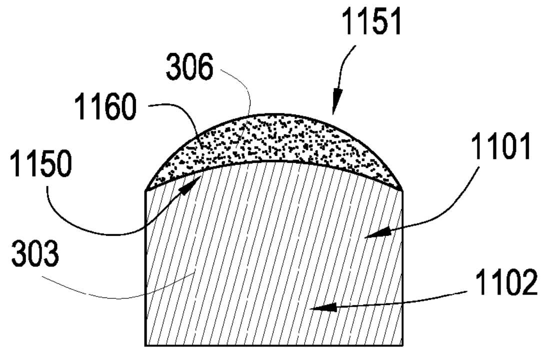

Fig. 12

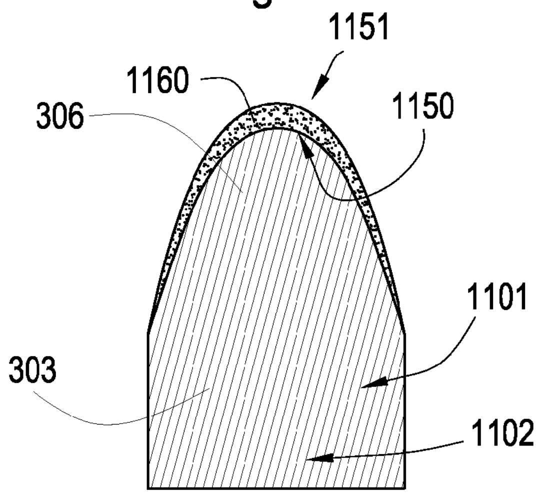

Fig. 13

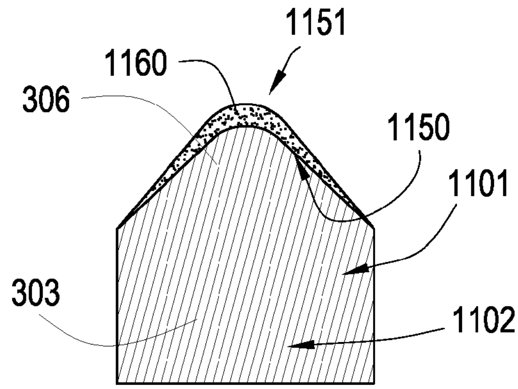

Fig. 14

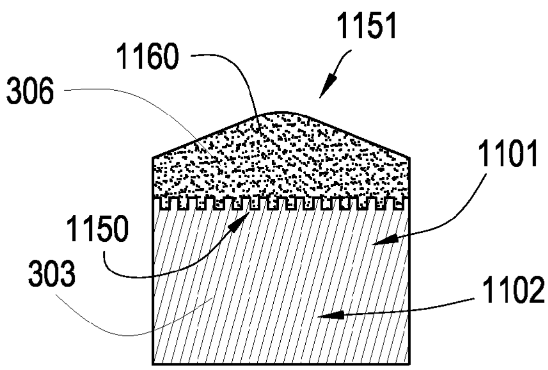

Fig. 15

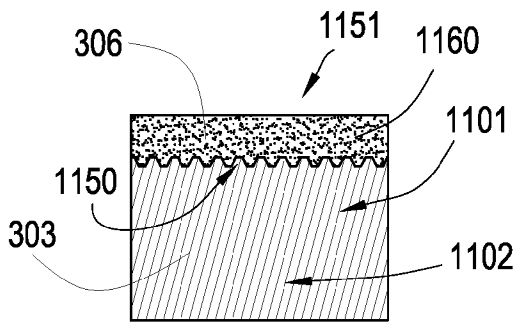

Fig. 16

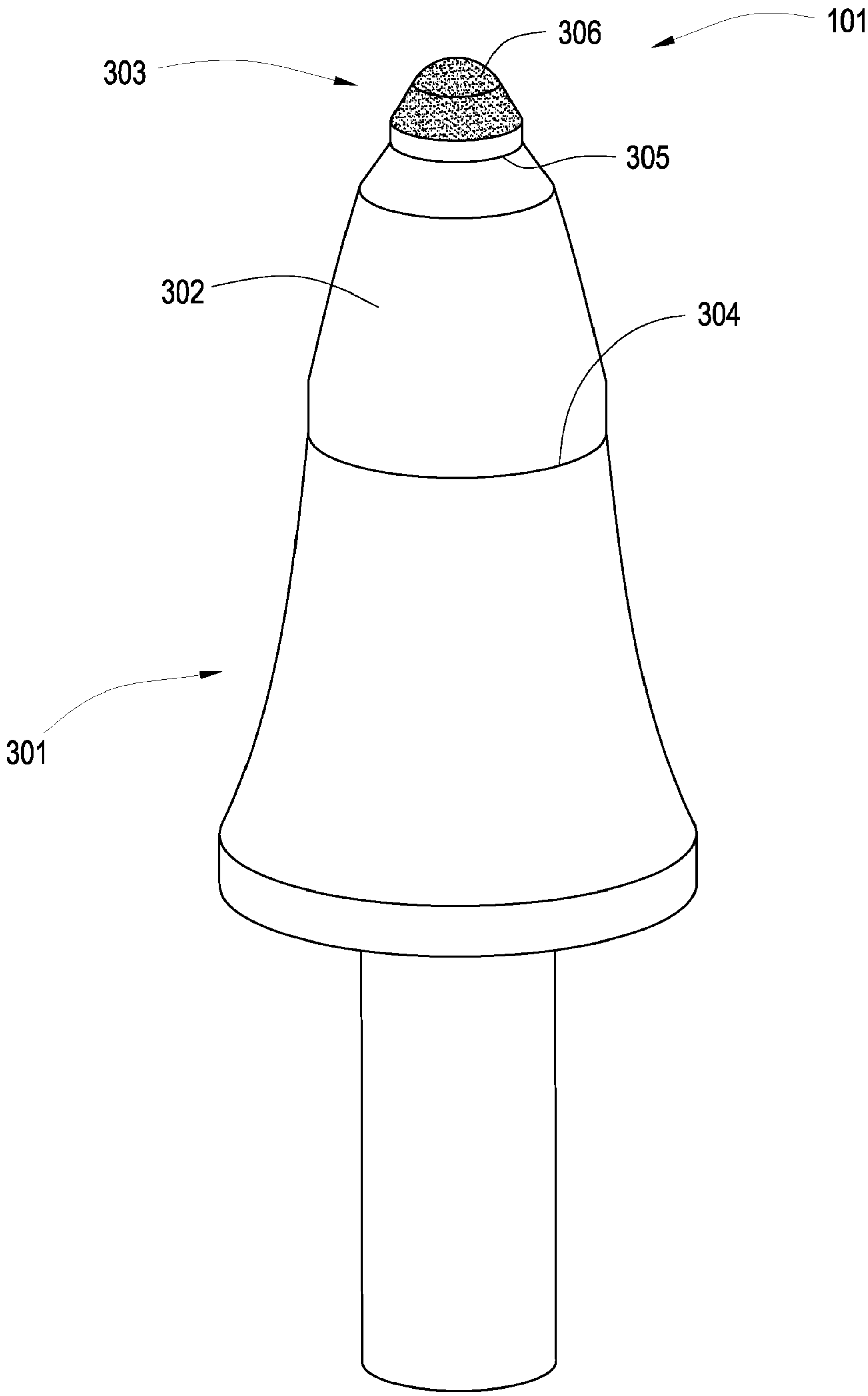

Fig. 17

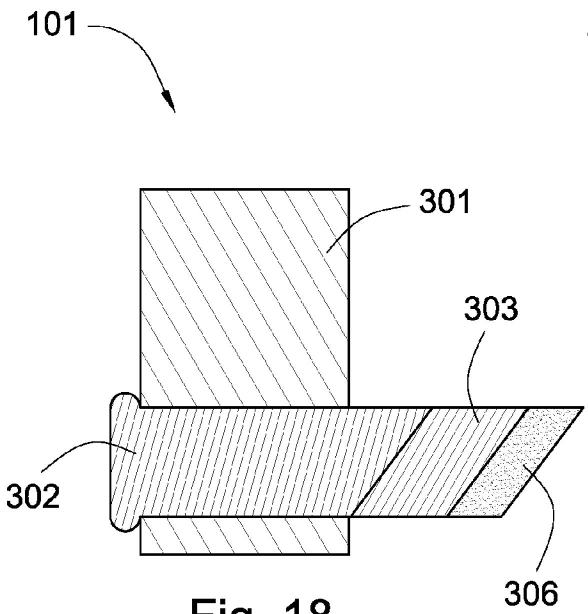

Fig. 18

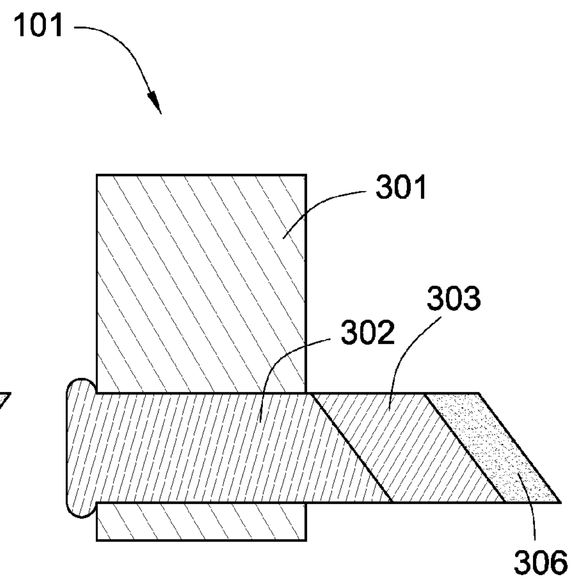

Fig. 19

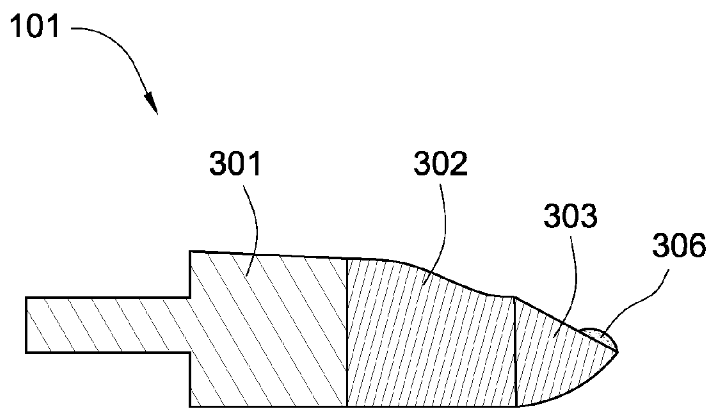

Fig. 20

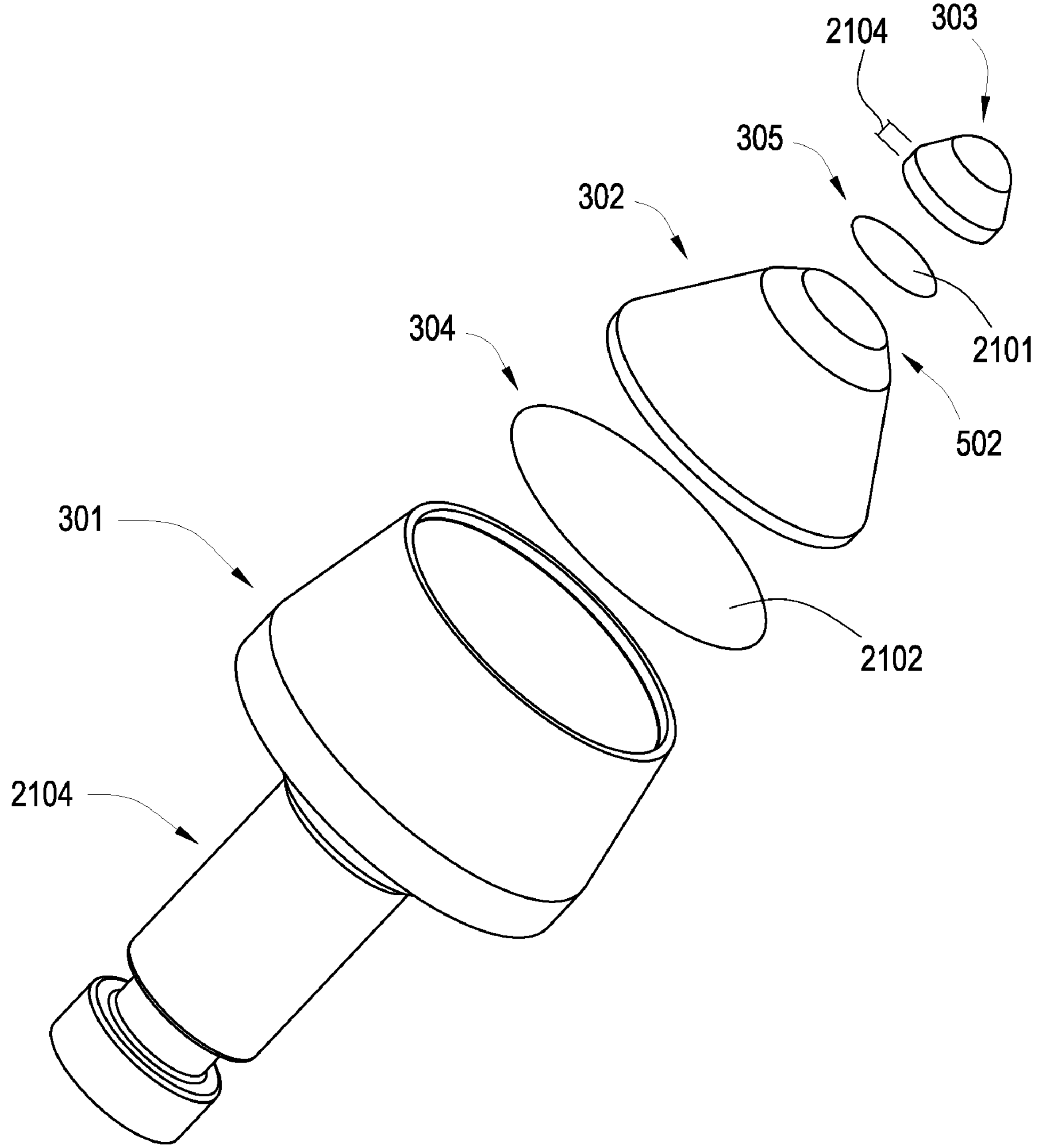

Fig. 21

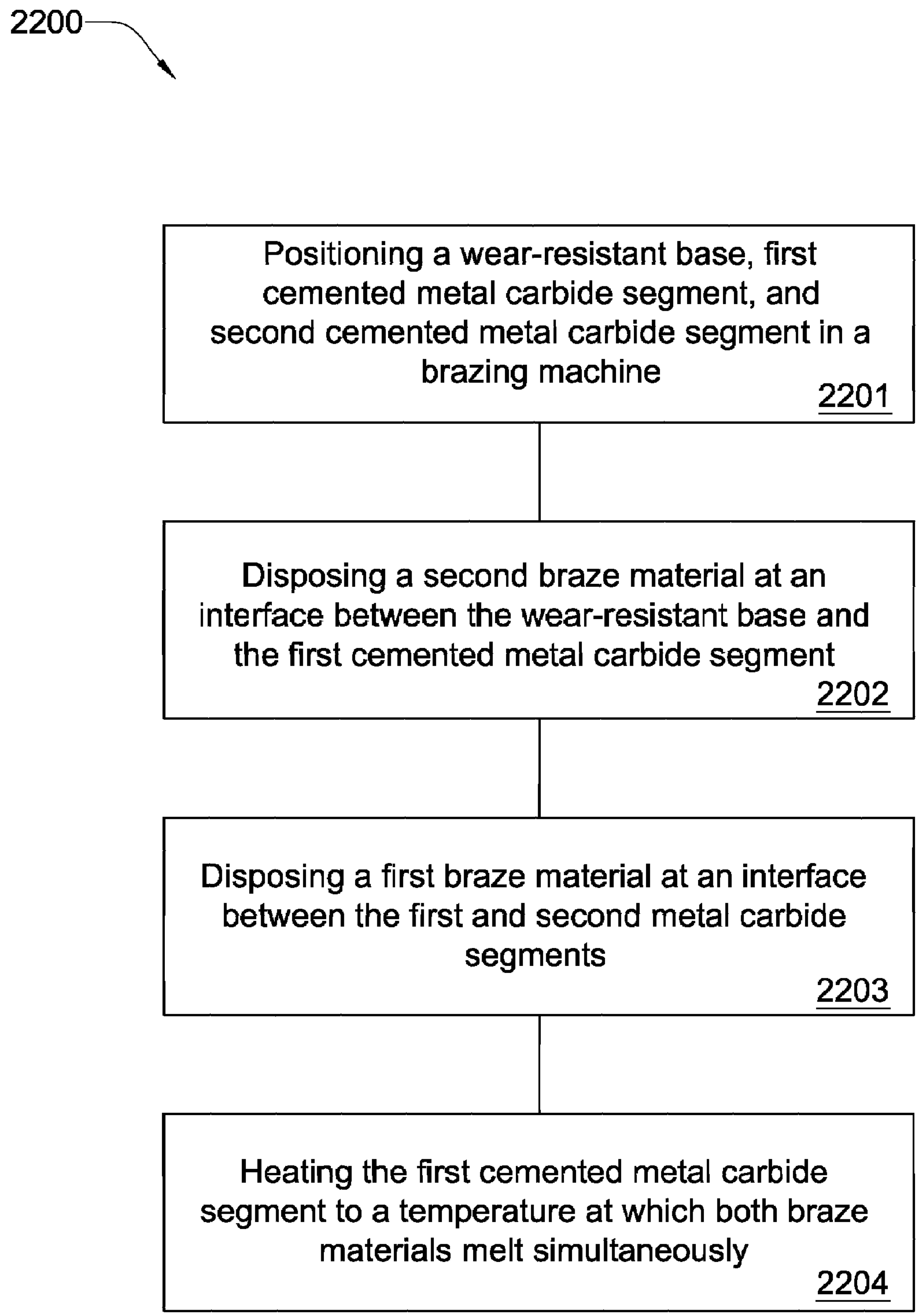
2200
Positioning a wear-resistant base, first cemented metal carbide segment, and second cemented metal carbide segment in a brazing machine
2201
Disposing a second braze material at an interface between the wear-resistant base and the first cemented metal carbide segment
2202
Disposing a first braze material at an interface between the first and second metal carbide segments
2203
Heating the first cemented metal carbide segment to a temperature at which both braze materials melt simultaneously
2204

Fig. 22

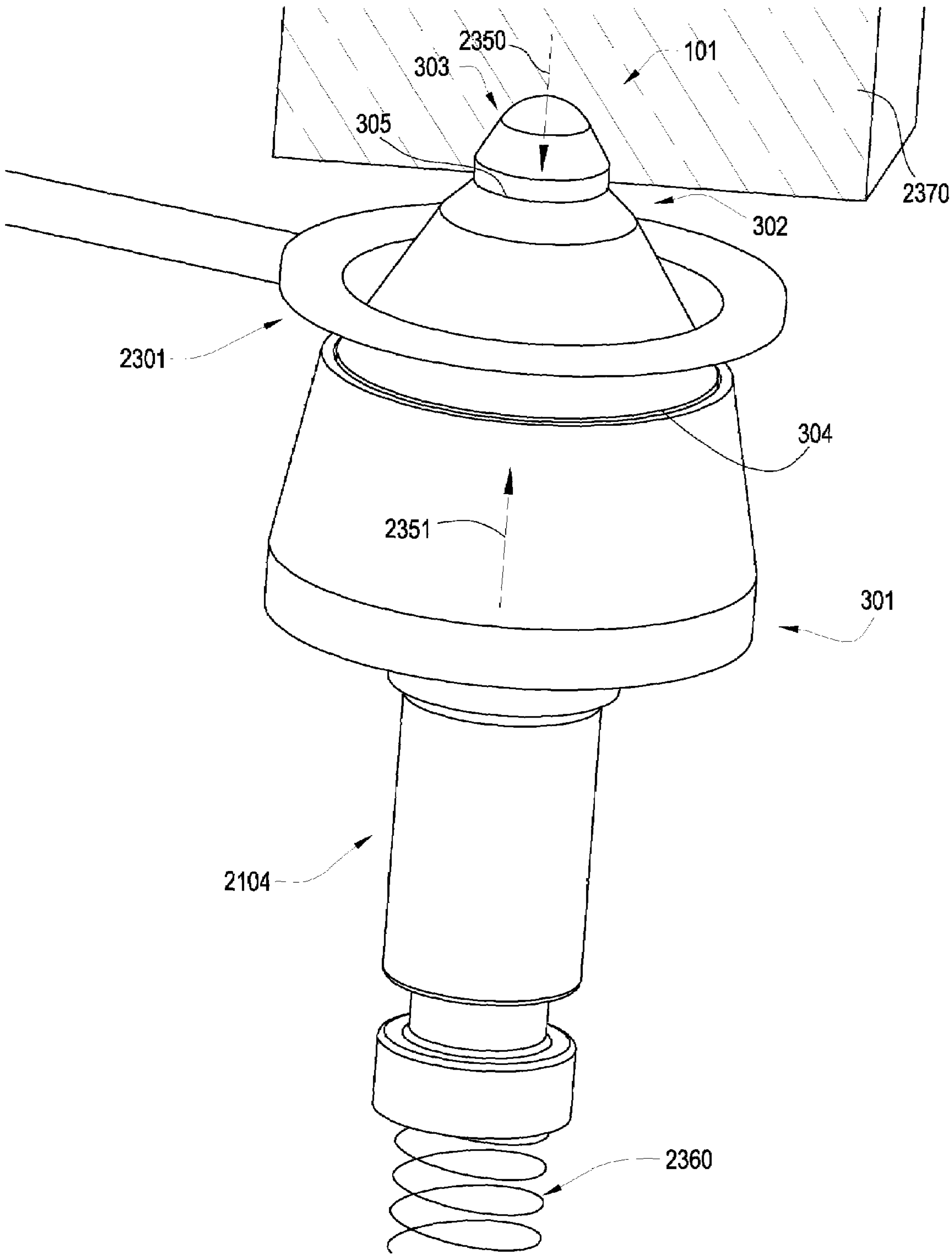

Fig. 23

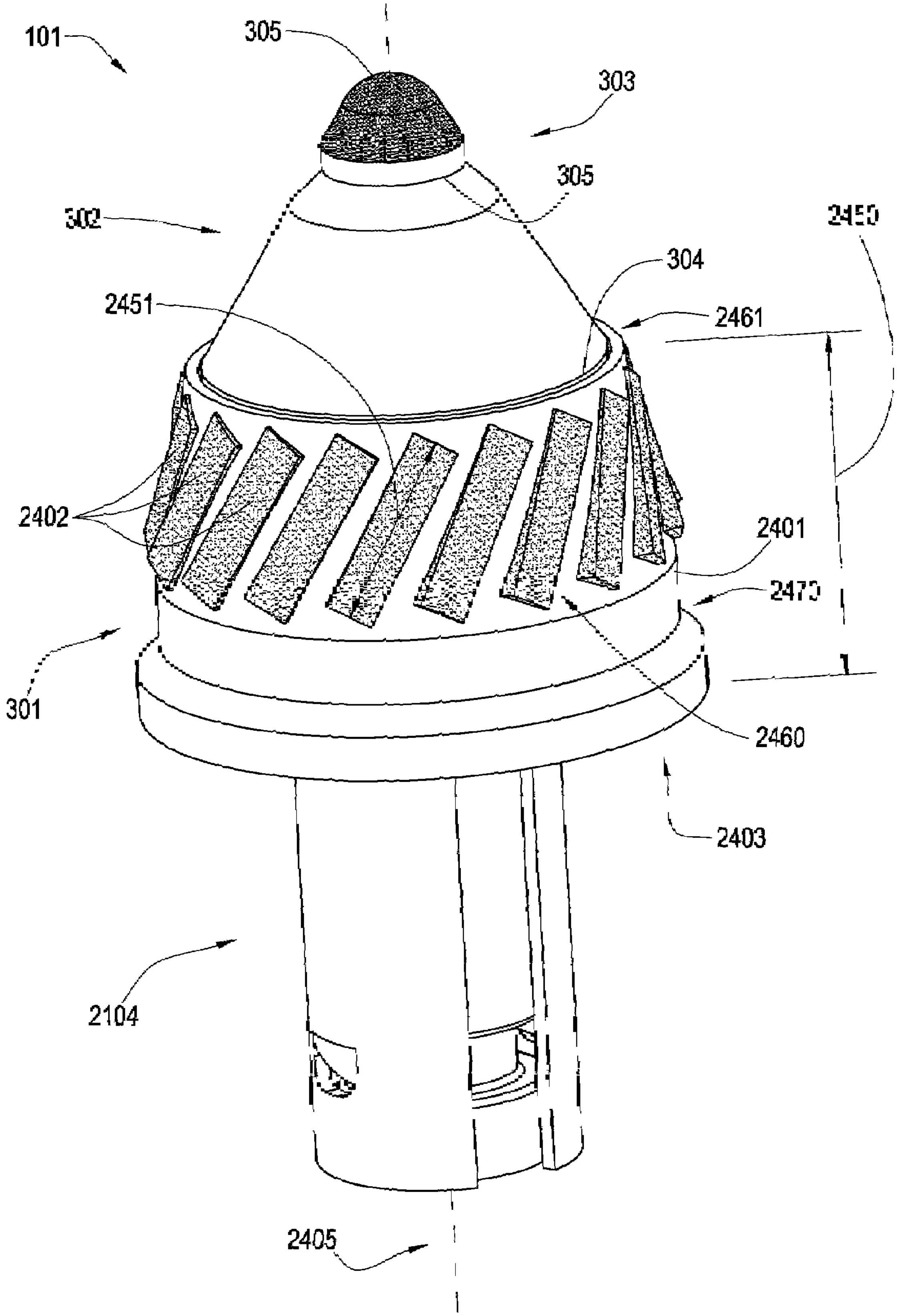
101
305
303
305
302
2450
304
2451
2461
2402
2401
2470
301
2460
2403
2104
2405

Fig. 24

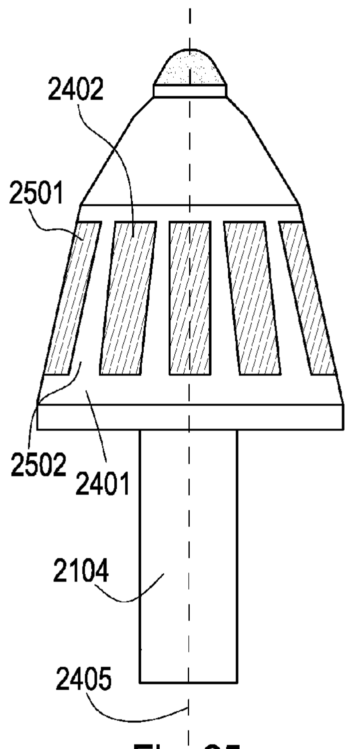

Fig. 25

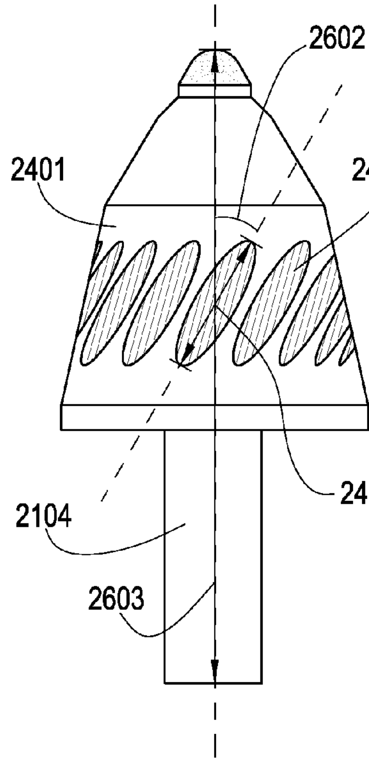

Fig. 26

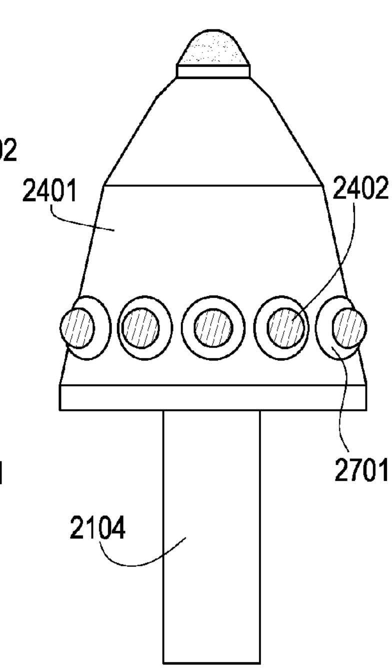

Fig. 27

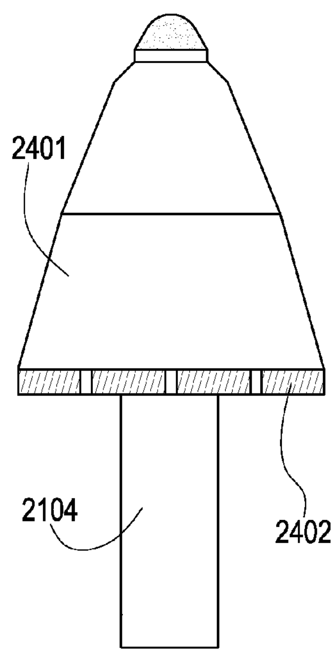

Fig. 28

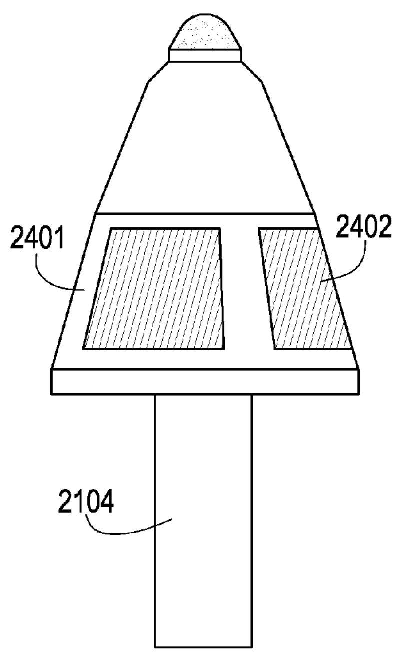

Fig. 29

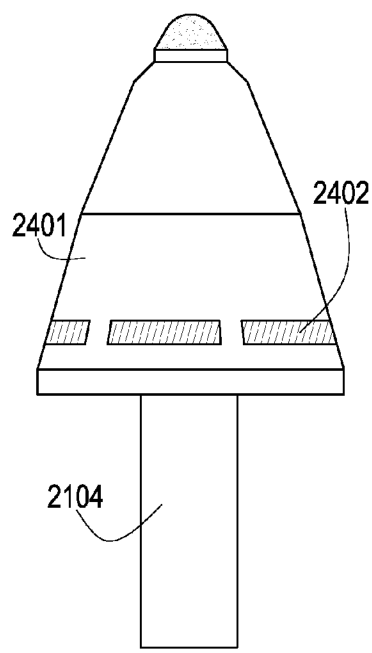

Fig. 30

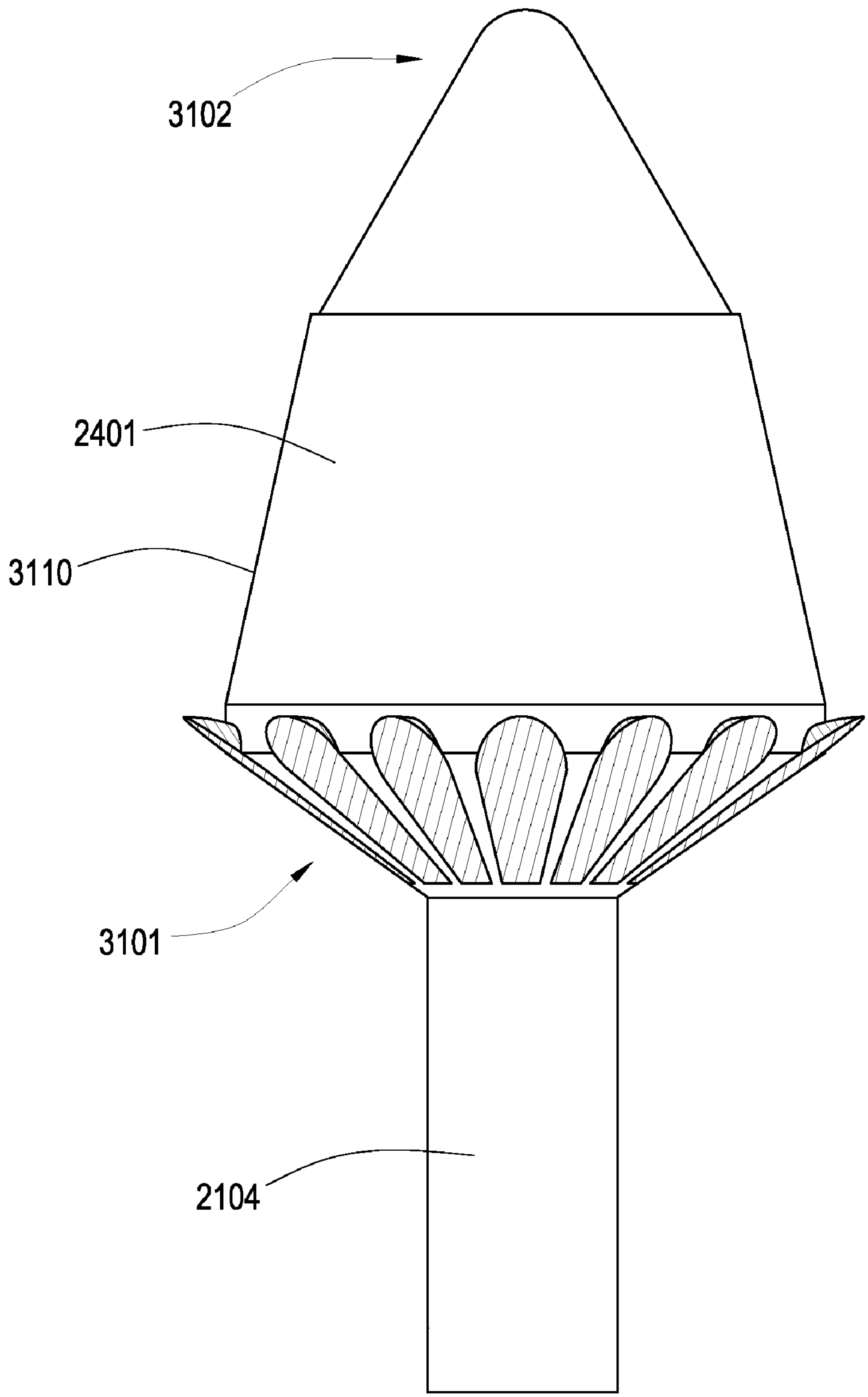

Fig. 31

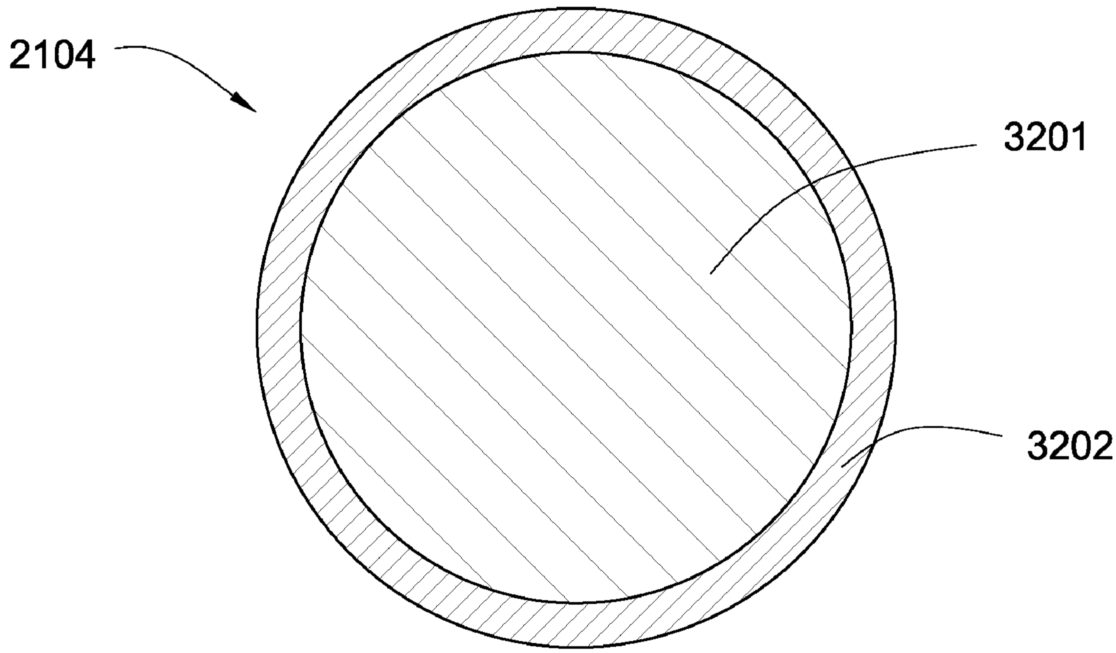

Fig. 32

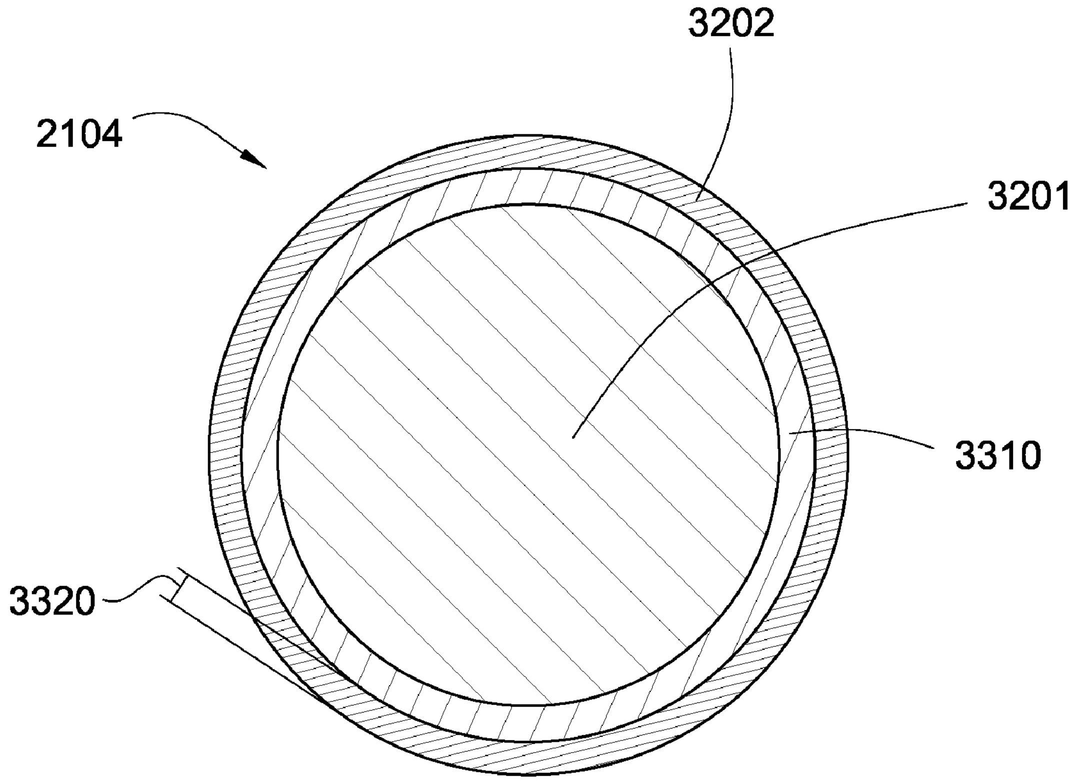

Fig. 33

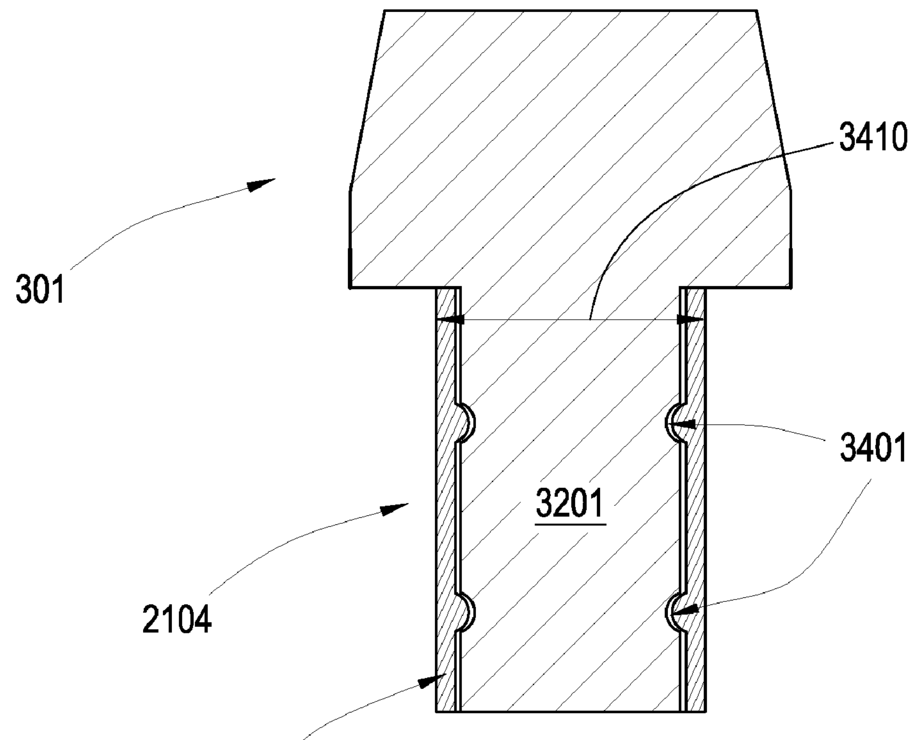

Fig. 34

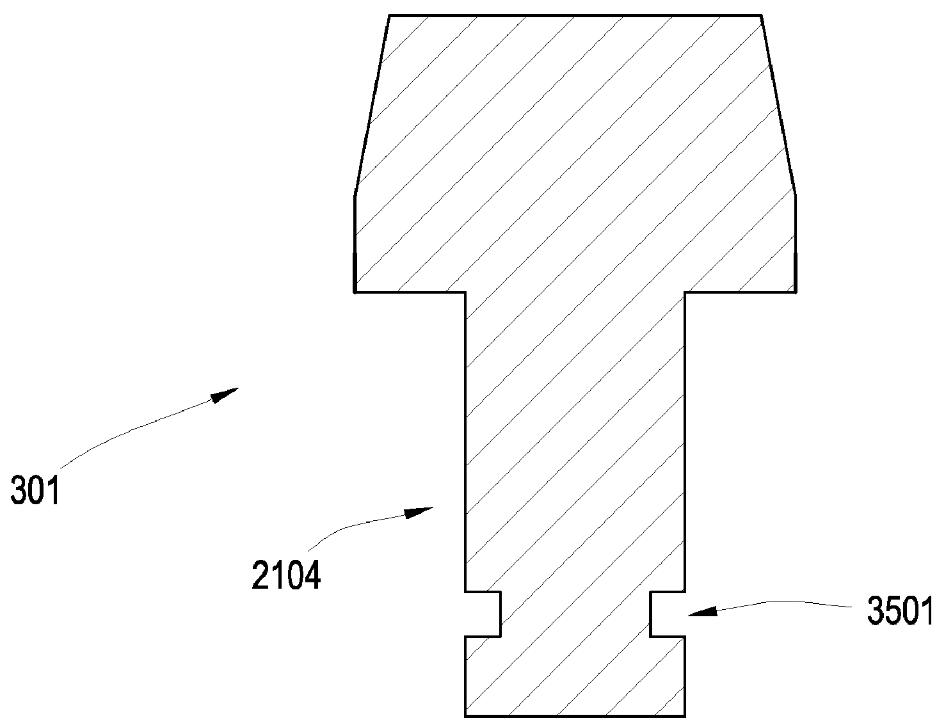

Fig. 35

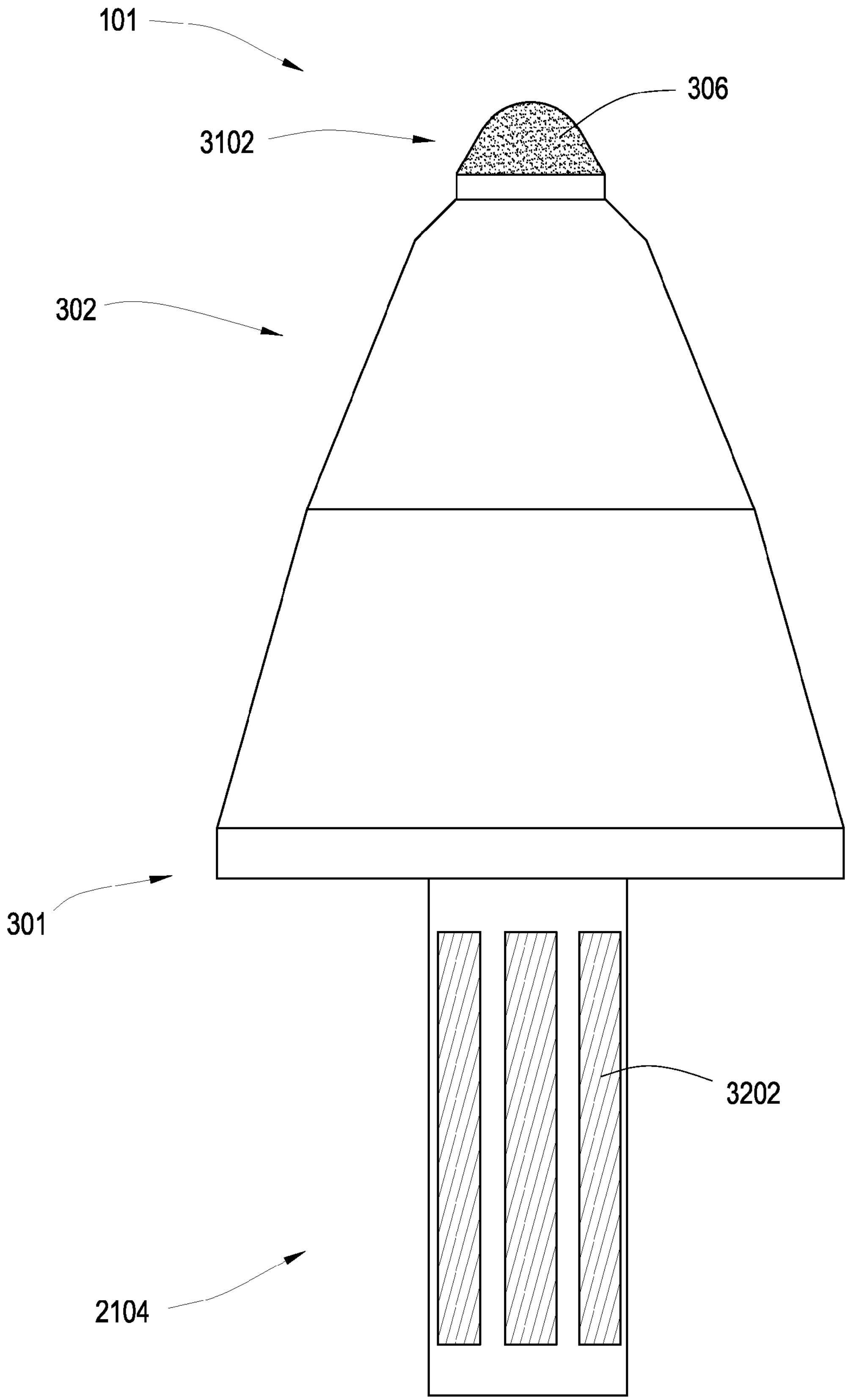

Fig. 36

ATTACK TOOL

CROSS REFERENCE IS RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 11/463,990 which was filed on Aug. 11, 2006 now U.S. Pat. No. 7,320,505 and entitled An Attack Tool. U.S. patent application Ser. No. 11/463,990 is a continuation-in-part of U.S. patent application Ser. No. 11/463,975 which was filed on Aug. 11, 2006 and entitled An Attack Tool. U.S. patent application Ser. No. 11/463,975 is a continuation in-part of U.S. patent application Ser. No. 11/463,962 which was filed on Aug. 11, 2006 and entitled An Attack Tool. All of these applications are herein incorporated by reference for all that it contains.

BACKGROUND OF THE INVENTION

Formation degradation, such as asphalt milling, mining, or excavating, may result in wear on attack tools. Consequently, many efforts have been made to extend the life of these tools. Examples of such efforts are disclosed in U.S. Pat. No. 4,944,559 to Sionnet et al., U.S. Pat. No. 5,837,071 to Andersson et al., U.S. Pat. No. 5,417,475 to Graham et al., U.S. Pat. No. 6,051,079 to Andersson et al., and U.S. Pat. No. 4,725,098 to Beach, all of which are herein incorporated by reference for all that they disclose.

BRIEF SUMMARY OF THE INVENTION

In one aspect of the invention, an attack tool has a wear-resistant base suitable for attachment to a driving mechanism. A first end of a generally frustoconical first cemented metal carbide segment bonded to the base. A second metal carbide segment is bonded to a second end of the first carbide segment at an interface opposite the base. The first end has a cross sectional thickness of about 0.250 to 0.750 inches and the second end has a cross sectional thickness of about 1 to 1.50 inches. The first cemented metal carbide segment also has a volume of 0.250 cubic inches to 0.600 cubic inches. In this disclosure, the abbreviation "HRc" stands for the Rockwell Hardness "C" scale, and the abbreviation "HK" stands for Knoop Hardness.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional diagram of an embodiment of attack tools on a rotating drum attached to a motor vehicle.

FIG. **2** is an orthogonal diagram of an embodiment of an attack tool and a holder.

FIG. **3** is an orthogonal diagram of another embodiment of an attack tool.

FIG. **4** is an orthogonal diagram of another embodiment of an attack tool.

FIG. **5** is a perspective diagram of a first cemented metal carbide segment.

FIG. **6** is an orthogonal diagram of an embodiment of a first cemented metal carbide segment.

FIG. **7** is an orthogonal diagram of another embodiment of a first cemented metal carbide segment.

FIG. **8** is an orthogonal diagram of another embodiment of a first cemented metal carbide segment.

FIG. **9** is an orthogonal diagram of another embodiment of a first cemented metal carbide segment.

FIG. **10** is an orthogonal diagram of another embodiment of a first cemented metal carbide segment.

FIG. **11** is a cross-sectional diagram of an embodiment of a second cemented metal carbide segment and a superhard material.

FIG. **12** is a cross-sectional diagram of another embodiment of a second cemented metal carbide segment and a superhard material.

FIG. **13** is a cross-sectional diagram of another embodiment of a second cemented metal carbide segment and a superhard material.

FIG. **14** is a cross-sectional diagram of another embodiment of a second cemented metal carbide segment and a superhard material.

FIG. **15** is a cross-sectional diagram of another embodiment of a second cemented metal carbide segment and a superhard material.

FIG. **16** is a cross-sectional diagram of another embodiment of a second cemented metal carbide segment and a superhard material.

FIG. **17** is a perspective diagram of another embodiment of an attack tool.

FIG. **18** is an orthogonal diagram of an alternate embodiment of an attack tool.

FIG. **19** is an orthogonal diagram of another alternate embodiment of an attack tool.

FIG. **20** is an orthogonal diagram of another alternate embodiment of an attack tool.

FIG. **21** is an exploded perspective diagram of another embodiment of an attack tool.

FIG. **22** is a schematic of a method of manufacturing an attack tool.

FIG. **23** is a perspective diagram of tool segments being brazed together.

FIG. **24** is a perspective diagram of an embodiment of an attack tool with inserts bonded to the wear-resistant base.

FIG. **25** is an orthogonal diagram of an embodiment of insert geometry.

FIG. **26** is an orthogonal diagram of another embodiment of insert geometry.

FIG. **27** is an orthogonal diagram of another embodiment of insert geometry.

FIG. **28** is an orthogonal diagram of another embodiment of insert geometry.

FIG. **29** is an orthogonal diagram of another embodiment of insert geometry.

FIG. **30** is an orthogonal diagram of another embodiment of insert geometry.

FIG. **31** is an orthogonal diagram of another embodiment of an attack tool.

FIG. **32** is a cross-sectional diagram of an embodiment of a shank.

FIG. **33** is a cross-sectional diagram of another embodiment of a shank.

FIG. **34** is a cross-sectional diagram of an embodiment of a shank.

FIG. **35** is a cross-sectional diagram of another embodiment of a shank.

FIG. **36** is an orthogonal diagram of another embodiment of a shank.

DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

It will be readily understood that the components of the present invention, as generally described and illustrated in the Figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following more

detailed description of embodiments of the methods of the present invention, as represented in the Figures is not intended to limit the scope of the invention, as claimed, but is merely representative of various selected embodiments of the invention.

The illustrated embodiments of the invention will best be understood by reference to the drawings, wherein like parts are designated by like numerals throughout. Those of ordinary skill in the art will, of course, appreciate that various modifications to the methods described herein may easily be made without departing from the essential characteristics of the invention, as described in connection with the Figures. Thus, the following description of the Figures is intended only by way of example, and simply illustrates certain selected embodiments consistent with the invention as claimed herein.

FIG. **1** is a cross-sectional diagram of an embodiment of an attack tool **101** on a rotating drum **102** attached to a motor vehicle **103**. The motor vehicle **103** may be a cold planer used to degrade manmade formations such as pavement **104** prior to the placement of a new layer of pavement, a mining vehicle used to degrade natural formations, or an excavating machine. Tools **101** may be attached to a drum **102** or a chain which rotates so the tools **101** engage a formation. The formation that the tool **101** engages may be hard and/or abrasive and cause substantial wear on tools **101**. The wear-resistant tool **101** may be selected from the group consisting of drill bits, asphalt picks, mining picks, hammers, indenters, shear cutters, indexable cutters, and combinations thereof. In large operations, such as pavement degradation or mining, when tools **101** need to be replaced the entire operation may cease while crews remove worn tools **101** and replace them with new tools **101**. The time spent replacing tools **101** may be costly.

FIG. **2** is an orthogonal diagram of an embodiment of a tool **101** and a holder **201**. A tool **101**/holder **201** combination is often used in asphalt milling and mining. A holder **201** is attached to a driving mechanism, which may be a rotating drum **102**, and the tool **101** is inserted into the holder **201**. The holder **201** may hold the tool **101** at an angle offset from the direction of rotation, such that the tool **101** optimally engages a formation.

FIG. **3** is an orthogonal diagram of an embodiment of a tool **101** with a first cemented metal carbide segment with a first volume. The tool **101** comprises a base **301** suitable for attachment to a driving mechanism, a first cemented metal carbide segment **302** bonded to the base **301** at a first interface **304**, and a second metal carbide segment **303** bonded to the first carbide segment **302** at a second interface **305** opposite the base **301**. The first cemented metal carbide segment **302** may comprise a first volume of 100 cubic inches to 2 cubic inches. Such a volume may be beneficial in absorbing impact stresses and protecting the rest of the tool **101** from wear. The first and/or second interfaces **304**, **305** may be planar as well. The first and/or second metal carbide segments **302**, **303** may comprise tungsten titanium, tantalum, molybdenum, niobium, cobalt and/or combinations thereof.

Further, the tool **101** may comprise a ratio of the length **350** of the first cemented metal carbide segment **302** to the length of the whole attack tool **351** which is 1/10 to 1/2; preferably the ratio is 1/7 to 1/2.5. The wear-resistant base **301** may comprise a length **360** that is at least half of the tool's length **351**.

FIG. **4** is an orthogonal diagram of an embodiment of a tool with a first cemented metal carbide segment with a second volume, which is less than the first volume. This may help to reduce the weight of the tool **101** which may require less horsepower to move or it may help to reduce the cost of the attack tool.

FIG. **5** is a perspective diagram of a first cemented metal carbide segment. The volume of the first segment **302** may be 0.100 to 2 cubic inches; preferably the volume may be 0.350 to 0.550 cubic inches. The first segment **302** may comprise a height **501** of 0.2 inches to 2 inches; preferably the height **501** may be 0.500 inches to 0.800 inches. The first segment **302** may comprise an upper cross-sectional thickness **502** of 0.250 to 0.750 inches; preferably the upper cross-sectional thickness **502** may be 0.300 inches to 0.500 inches. The first segment **302** may also comprise a lower cross-sectional thickness **503** of 1 inch to 1.5 inches; preferably the lower cross-sectional thickness **503** may be 1.10 inches to 1.30 inches. The upper and lower cross-sectional thicknesses **502**, **503** may be planar. The first segment **302** may also comprise a nonuniform cross-sectional thickness. Further, the segment **302** may have features such as a chamfered edge **505** and a ledge **506** to optimize bonding and/or improve performance.

FIGS. **6-10** are orthogonal diagrams of several embodiments of a first cemented metal carbide segment. Each figure discloses planar upper and lower ends **601**, **602**. When the ends **601**, **602** are bonded to the base **301** and second segment **303**, the resulting interfaces **304**, **305** may also be planar. In other embodiments, the ends comprise a non-planar geometry such as a concave portion, a convex portion, ribs, splines, recesses, protrusions, and/or combinations thereof.

The first segment **302** may comprise various geometries. The geometry may be optimized to move cuttings away from the tool **101**, distribute impact stresses, reduce wear, improve degradation rates, protect other parts of the tool **101**, and/or combinations thereof. The embodiments of FIGS. **6** and **7**, for instance, may be useful for protecting the tool **101**. FIG. **6** comprises an embodiment of the first segment **302** without features such as a chamfered edge **505** and a ledge **506**. The bulbous geometry of the first segment **302** in FIGS. **8** and **9** may be sacrificial and may extend the life of the tool **101**. A segment **302** as disclosed in FIG. **10** may be useful in moving cuttings away from the tool **101** and focusing cutting forces at a specific point.

FIGS. **11-16** are cross-sectional diagrams of several embodiments of a second cemented metal carbide segment and a superhard material. The second cemented metal carbide segment **303** may be bonded to a superhard material **306** opposite the interface **304** between the first segment **302** and the base **301**. In other embodiments, the superhard material is bonded to any portion of the second segment. The interface **1150** between the second segment **303** and the superhard material **306** may be non-planar or planar. The superhard material **306** may comprise polycrystalline diamond, vapor-deposited diamond, natural diamond, cubic boron nitride, infiltrated diamond, layered diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, or combinations thereof. The superhard material may be at least 4,000 HK and in some embodiments it may be 1 to 20000 microns thick. In embodiments, where the superhard material is a ceramic, the material may comprise a region **1160** (preferably near its surface **1151**) that is free of binder material. The average grain size of a superhard ceramic may be 10 to 100 microns in size. Infiltrated diamond is typical made by sintering the superhard material adjacent a cemented metal carbide and allowing a metal (such as cobalt) to infiltrate into the

superhard material. The superhard material may be a synthetic diamond comprising a binder concentration of 4 to 35 weight percent.

The second segment **303** and superhard material may comprise many geometries. In FIG. **11** the second segment **303** has a relatively small surface area to bind with the superhard material reducing the amount of superhard material required and reducing the overall cost of the attack tool. In embodiments, where the superhard material is a polycrystalline diamond, the smaller the second carbide segment the cheaper it may be to produce large volumes of attack tool since more second segments may be placed in a high temperature high pressure apparatus at once. The superhard material **306** in FIG. **11** comprises a semi-round geometry. The superhard material in FIG. **12** comprises a domed geometry. The superhard material **306** in FIG. **13** comprises a mix of domed and conical geometry. Blunt geometries, such as those disclosed in FIGS. **11**-**13** may help to distribute impact stresses during formation degradation, but cutting efficiency may be reduced. The superhard material **306** in FIG. **14** comprises a conical geometry. The superhard material **306** in FIG. **15** comprises a modified conical geometry, and the superhard material in FIG. **16** comprises a flat geometry. Sharper geometries, such as those disclosed in FIGS. **14** and **15**, may increase cutting efficiency, but more stress may be concentrated to a single point of the geometry upon impact. A flat geometry may have various benefits when placed at a positive cutting rake angle or other benefits when placed at a negative cutting rake angle.

The second segment **303** may comprise a region **1102** proximate the second interface **305** which may comprise a higher concentration of a binder than a distal region **1101** of the second segment **303** to improve bonding or add elasticity to the tool. The binder may comprise cobalt, iron, nickel, ruthenium, rhodium, palladium, chromium, manganese, tantalum, or combinations thereof.

FIG. **17** is a perspective diagram of another embodiment of a tool. Such a tool **101** may be used in mining. Mining equipment, such as continuous miners, may use a driving mechanism to which tools **101** may be attached. The driving mechanism may be a rotating drum **102**, similar to that used in asphalt milling, which may cause the tools **101** to engage a formation, such as a vein of coal or other natural resources. Tools **101** used in mining may be elongated compared to similar tools **101** like picks used in asphalt cold planars.

FIGS. **18**-**20** are cross-sectional diagrams of alternate embodiments of an attack tool. These tools are adapted to remain stationary within the holder **201** attached to the driving mechanism. Each of the tools **101** may comprise a base segment **301** which may comprise steel, a cemented metal carbide, or other metal. The tools **101** may also comprise first and second segments **302**, **303** bonded at interfaces **304**, **305**. The angle and geometry of the superhard material **306** may be altered to change the cutting ability of the tool **101**. Positive or negative rake angles may be used along with geometries that are semi-rounded, rounded, domed, conical, blunt, sharp, scoop, or combinations thereof. Also the superhard material may be flush with the surface of the carbide or it may extend beyond the carbide as well.

FIG. **21** is an exploded perspective diagram of an embodiment of an attack tool. The tool **101** comprises a wear-resistant base **301** suitable for attachment to a driving mechanism, a first cemented metal carbide segment **302** brazed to the wear-resistant base at a first interface **304**, a second cemented metal carbide segment **303** brazed to the first cemented metal carbide segment **302** at a second interface **305** opposite the wear-resistant base **301**, a shank **2104**, and a braze material **2101** disposed in the second interface **305** comprising 30 to 62 weight percent of palladium. Preferably, the braze material comprises 40 to 50 weight percent of palladium.

The braze material **2101** may comprise a melting temperature from 700 to 1200 degrees Celsius; preferably the melting temperature is from 800 to 970 degrees Celsius. The braze material may comprise silver, gold, copper nickel, palladium, boron, chromium, silicon, germanium, aluminum, iron, cobalt, manganese, titanium, tin, gallium, vanadium, phosphorus, molybdenum, platinum, or combinations thereof. The braze material **2101** may comprise 30 to 60 weight percent nickel, 30 to 62 weight percent palladium, and 3 to 15 weight percent silicon; preferably the first braze material **2101** may comprise 47.2 weight percent nickel, 46.7 weight percent palladium, and 6.1 weight percent silicon. Active cooling during brazing may be critical in some embodiments, since the heat from brazing may leave some residual stress in the bond between the second carbide segment and the superhard material. The second carbide segment **303** may comprise a length of 0.1 to 2 inches. The superhard material **306** may be 0.020 to 1100 inches away from the interface **305**. The further away the superhard material **306** is, the less thermal damage is likely to occur during brazing. Increasing the distance **2104** between the interface **305** and the superhard material **306**, however, may increase the moment on the second carbide segment and increase stresses at the interface **305** upon impact.

The first interface **304** may comprise a second braze material **2102** which may comprise a melting temperature from 800 to 1200 degrees Celsius. The second braze material **2102** may comprise 40 to 80 weight percent copper, 3 to 20 weight percent nickel, and 3 to 45 weight percent manganese; preferably the second braze material **2101** may comprise 67.5 weight percent copper, 9 weight percent nickel, and 23.5 weight percent manganese.

Further, the first cemented metal carbide segment **302** may comprise an upper end **601** and the second cemented metal carbide segment may comprise a lower end **602**, wherein the upper and lower ends **601**, **602** are substantially equal.

FIG. **22** is a schematic of a method of manufacturing a tool. The method **2200** comprises positioning **2201** a wear-resistant base **301**, first cemented metal carbide segment **302**, and second cemented metal carbide segment **303** in a brazing machine, disposing **2202** a second braze material **2102** at an interface **304** between the wear-resistant base **301** and the first cemented metal carbide segment **302**, disposing **2203** a first braze material **2101** at an interface **305** between the first and second cemented metal carbide segments **302**, **303**, and heating **2204** the first cemented metal carbide segment **302** to a temperature at which both braze materials melt simultaneously. The method **2200** may comprise an additional step of actively cooling the attack tool, preferably the second carbide segment **303**, while brazing. The method **2200** may further comprise a step of air-cooling the brazed tool **101**.

The interface **304** between the wear-resistant base **301** and the first segment **302** may be planar, and the interface **305** between the first and second segments **302**, **303** may also be planar. Further, the second braze material **2102** may comprise 50 to 70 weight percent of copper, and the first braze material **2101** may comprise 40 to 50 weight percent palladium.

FIG. **23** is a perspective diagram of tool segments being brazed together. The attack tool **101** may be assembled as

described in the above method **2200**. Force, indicated by arrows **2350** and **2351**, may be applied to the tool **101** to keep all components in line. A spring **2360** may urge the shank **2104** upwards and positioned within the machine (not shown). There are various ways to heat the first segment **302**, including using an inductive coil **2301**. The coil **2301** may be positioned to allow optimal heating at both interfaces **304**, **305** to occur. Brazing may occur in an atmosphere that is beneficial to the process. Using an inert atmosphere may eliminate elements such as oxygen, carbon, and other contaminates from the atmosphere that may contaminate the braze material **2101**, **2102**.

The tool may be actively cooled as it is being brazed. Specifically, the superhard material **306** may be actively cooled. A heat sink **2370** may be placed over at least part of the second segment **303** to remove heat during brazing. Water or other fluid may be circulated around the heat sink **2370** to remove the heat. The heat sink **2370** may also be used to apply a force on the tool **101** to hold it together while brazing.

FIG. **24** is a perspective diagram of an embodiment of a tool with inserts in the wear-resistant base. An attack tool **101** may comprise a wear-resistant base **301** suitable for attachment to a driving mechanism, the wear-resistant base comprising a shank **2104** and a metal segment **2401**; a cemented metal carbide segment **302** bonded to the metal segment **2401** opposite the shank **2104**; and at least one hard insert **2402** bonded to the metal segment **2401** proximate the shank wherein the insert **2402** comprises a hardness greater than 60 HRc. The metal segment **2401** may comprise a hardness of 40 to 50 HRc. The metal segment **2401** and shank **2104** may be made from the same piece of material.

The insert **2402** may comprise a material selected from the group consisting of diamond, natural diamond, polycrystalline diamond, cubic boron nitride, vapor-deposited diamond, diamond grit, polycrystalline diamond grit, cubic boron nitride grit, chromium, tungsten, titanium, molybdenum, niobium, a cemented metal carbide, tungsten carbide, aluminum oxide, zircon, silicon carbide, whisker reinforced ceramics, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, or combinations thereof as long as the hardness of the material is greater than 60 HRc. Having an insert **2402** that is harder than the metal segment **2401** may decrease the wear on the metal segment **2401**. The insert **2402** may comprise a cross-sectional thickness of 0.030 to 0.500 inches. The insert **2402** may comprise an axial length **2451** less than an axial length **2450** of the metal segment **2402**, and the insert **2402** may comprise a length shorter than a circumference **2470** of the metal segment **2401** proximate the shank **2104**. The insert **2402** may be brazed to the metal segment **2401**. The insert **2402** may be a ceramic with a binder comprising 4 to 35 weight percent of the insert. The insert **2402** may also be polished.

The base **301** may comprise a ledge **2403** substantially normal to an axial length of the tool **101**, the axial length being measured along the axis **2405** shown. At least a portion of a perimeter **2460** of the insert **2402** may be within 0.5 inches of the ledge **2403**. If the ratio of the length **350** of the first cemented metal carbide segment **302** to the length of the whole attack tool **351** may be 1/10 to 1/2, the wear-resistant base **301** may comprise as much as 9/10 to 1/2 of the tool **101**. An insert's axial length **2451** may not exceed the length of the wear-resistant base's length **360**. The insert's perimeter **2460** may extend to the edge **2461** of the wear-resistant base **301**, but the first carbide segment **302** may be free of an insert **2402**. The insert **2402** may be disposed entirely on the wear-resistant base **301**. Further, the metal segment **2401** may comprise a length **2450** which is greater than the insert's length **2451**; the perimeter **2460** of the insert **2402** may not extend beyond the ledge **2403** of the metal segment **2401** or beyond the edge of the metal segment **2461**.

Inserts **2402** may also aid in tool rotation. Attack tools **101** often rotate within their holders upon impact which allows wear to occur evenly around the tool **101**. The inserts **2402** may be angled such so that it cause the tool **101** to rotate within the bore of the holder.

FIGS. **25-30** are orthogonal diagrams of several embodiments of insert geometries. The insert **2402** may comprise a generally circular shape, a generally rectangular shape, a generally annular shape, a generally spherical shape, a generally pyramidal shape, a generally conical shape, a generally accurate shape, a generally asymmetric shape, or combinations thereof. The distal most surface **2501** of the insert **2402** may be flush with the surface **2502** of the wear-resistant base **301**, extend beyond the surface **2502** of the wear-resistant base **301**, be recessed into the surface **2502** of the wear-resistant base, or combinations thereof. An example of the insert **2402** extending beyond the surface **2502** of the base **301** is seen in if FIG. **24**. FIG. **25** discloses generally rectangular inserts **2402** that are aligned with a central axis **2405** of the tool **101**.

FIG. **26** discloses an insert **2402** comprising an axial length **2451** forming an angle **2602** of 1 to 75 degrees with an axial length **2603** of the tool **101**. The inserts **2402** may be oblong.

FIG. **27** discloses a circular insert **2402** bonded to a protrusion **2701** formed in the base. The insert **2402** may be flush with the surface of the protrusion **2701**, extend beyond the protrusion **2701**, or be recessed within the protrusion **2701**. A protrusion **2701** may help extend the insert **2402** so that the wear is decreased as the insert **2402** takes more of the impact. FIGS. **28-30** disclose segmented inserts **2402** that may extend considerably around the metal segment's circumference **2470**. The angle formed by insert's axial length **2601** may also be 90 degrees from the tool's axial length **2603**.

FIG. **31** is an orthogonal diagram of another embodiment of a tool. The base **301** of an attack tool **101** may comprise a tapered region **3101** intermediate the metal segment **2401** and the shank **2104**. An insert **2402** may be bonded to the tapered region **3101**, and a perimeter of the insert **2402** may be within 0.5 inches of the tapered region **3101**. The inserts **2402** may extend beyond the perimeter **3110** of the tool **101**. This may be beneficial in protecting the metal segment. A tool tip **3102** may be bonded to a cemented metal carbide, wherein the tip may comprise a layer selected from the group consisting of diamond, natural diamond, polycrystalline diamond, cubic boron nitride, infiltrated diamond, or combinations thereof. In some embodiments, a tip **3102** is formed by the first carbide segment. The first carbide segment may comprise a superhard material bonded to it although it is not required.

FIGS. **32** and **33** are cross-sectional diagrams of embodiments of the shank. An attack tool may comprise a wear-resistant base suitable for attachment to a driving mechanism, the wear-resistant base comprising a shank **2104** and a metal segment **2401**; a cemented metal carbide segment bonded to the metal segment; and the shank comprising a wear-resistant surface **3202**, wherein the wear-resistant surface **3202** comprises a hardness greater than 60 HRc.

The shank **2104** and the metal segment **2401** may be formed from a single piece of metal. The base may comprise steel having a hardness of 35 to 50 HRc. The shank **2104**

may comprise a cemented metal carbide, steel, manganese, nickel, chromium, titanium, or combinations thereof. If a shank **2104** comprises a cemented metal carbide, the carbide may have a binder concentration of 4 to 35 weight percent. The binder may be cobalt.

The wear-resistant surface **3202** may comprise a cemented metal carbide, chromium, manganese, nickel, titanium, hard surfacing, diamond, cubic boron nitride, polycrystalline diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, deposited diamond, aluminum oxide, zircon, silicon carbide, whisker reinforced ceramics, or combinations thereof. The wear-resistant surface **3202** may be bonded to the shank **2104** though the processes of electroplating, cladding, electroless plating, thermal spraying, annealing, hard facing, applying high pressure, hot dipping, brazing, or combinations thereof. The surface **3202** may comprise a thickness **3220** of 0.001 to 0.200 inches. The surface **3202** may be polished. The shank **2104** may also comprise layers. A core **3201** may comprise steel, surrounded by a layer of another material, such as tungsten carbide. There may be one or more intermediate layers **3310** between the core **3201** and the wear-resistant surface **3202** that may help the wear-resistant surface **3202** bond to the core. The wear-resistant surface **3202** may also comprise a plurality of layers **3201**, **3310**, **3202**. The plurality of layers may comprise different characteristics selected from the group consisting of hardness, modulus of elasticity, strength, thickness, grain size, metal concentration, weight, and combinations thereof. The wear-resistant surface **3202** may comprise chromium having a hardness of 65 to 75 HRc.

FIGS. **34** and **35** are orthogonal diagrams of embodiments of the shank. The shank **2401** may comprise one or more grooves **3401**. The wear-resistant surface **3202** may be disposed within a groove **3401** formed in the shank **2104**. Grooves **3401** may be beneficial in increasing the bond strength between the wear-resistant surface **3202** and the core **3201**. The bond may also be improved by swaging the wear-resistant surface **3202** on the core **3201** of the shank **2104**. Additionally, the wear-resistant surface **3202** may comprise a nonuniform diameter **3501**. The nonuniform diameter **3501** may help hold a retaining member (not shown) while the tool **101** is in use. The entire cross-sectional thickness **3410** of the shank may be harder than 60 HRc. In some embodiments, the shank may be made of a solid cemented metal carbide, or other material comprising a hardness greater than 60 HRc.

FIG. **36** is an orthogonal diagram of another embodiment of the shank. The wear-resistant surface **3202** may be segmented. Wear-resistant surface **3202** segments may comprise a height less than the height of the shank **2104**. The tool **101** may also comprise a tool tip **3102** which may be bonded to the cemented metal carbide segment **302** and may comprise a layer selected from the group consisting of diamond, natural diamond synthetic diamond, polycrystalline diamond, infiltrated diamond, cubic boron nitride, or combinations thereof. The polycrystalline diamond may comprise a binder concentration of 4 to 35 weight percent.

What is claimed is:

1. An attack tool, comprising:

a wear-resistant base with a shank suitable for attachment to a driving mechanism;

a first cemented metal carbide segment substantially coaxial with the shank and attached to the wear-resistant base at a first interface;

a second cemented metal carbide segment brazed to the first cemented metal carbide segment at a second interface opposite the wear-resistant base; and

a braze material disposed in the second interface and comprising 30 to 62 weight percent of palladium;

wherein diamond is bonded to the second cemented metal carbide segment and is 0.020 to 0.100 inches away from the second interface.

2. The tool of claim **1**, wherein the tool is selected from the group consisting of asphalt picks, mining picks, hammers, indenters, shear cutters, indexable cutters, and combinations thereof.

3. The tool of claim **1**, wherein the first cemented metal carbide segment comprises a volume of 0.250 cubic inches to 0.600 cubic inches.

4. The tool of claim **1**, wherein the second cemented metal carbide segment comprises a region bonded to the diamond selected from the group consisting of layered diamond, infiltrated diamond, natural diamond, polycrystalline diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, or combinations thereof.

5. The tool of claim **1**, wherein the braze material comprises silver, gold, copper, nickel, palladium, boron, chromium, silicon, germanium, aluminum, iron, cobalt, manganese, titanium, tin, gallium, vanadium, indium, phosphorus, molybdenum, platinum, or combinations thereof.

6. The tool of claim **1**, wherein the braze material comprises a melting temperature from 700 to 1100 degrees Celsius.

7. The tool of claim **6**, wherein the braze material comprises 30 to 60 weight percent nickel and 3 to 15 weight percent silicon.

8. The tool of claim **6**, wherein the braze material comprises 47.2 weight percent nickel, 46.7 weight percent palladium, and 6.1 weight percent silicon.

9. The tool of claim **1**, wherein the first interface comprises a second braze material comprises a melting temperature from 800 to 1200 degrees Celsius.

10. The tool of claim **9**, wherein the second braze material comprises 40 to 80 weight percent copper, 3 to 20 weight percent nickel, and 3 to 45 weight percent manganese.

11. The tool of claim **9**, wherein the second braze material comprises 67.5 weight percent copper, 9 weight percent nickel, and 23.5 weight percent manganese.

12. The tool of claim **1**, wherein the first and/or second metal carbide segments comprise tungsten, titanium, tantalum, molybdenum, niobium, or combinations thereof.

13. The tool of claim **1**, wherein the first cemented metal carbide segment comprises an upper diameter and the second cemented metal carbide segment comprises a lower diameter, wherein the upper and lower diameters are substantially equal.

14. A method for brazing an attack tool, comprising:

positioning a wear-resistant base, first cemented metal carbide segment, and second cemented metal carbide segment in a brazing machine;

disposing a second braze material at a first interface between the wear-resistant base and the first cemented metal carbide segment;

disposing a first braze material at a second interface between the first and second cemented metal carbide segments, wherein diamond is bonded to the first cemented metal carbide segment and is 0.020 to 0.100 inches away from the second interface; and

heating the first cemented metal carbide segment to a temperature at which both braze materials melt simultaneously.

15. The method of claim **14**, wherein the interface between the first and second segments is planar.

16. The method of claim **14**, further comprising a step of air-cooling the brazed tool.

17. The method of claim **14**, wherein the braze material comprises silver, gold, copper, nickel, palladium, boron, chromium, silicon, germanium, aluminum, iron, cobalt, manganese, titanium, tin, gallium, vanadium, indium, phosphorus, molybdenum, platinum, or combinations thereof.

18. The method of claim **14**, wherein the second braze material comprises 50-70 weight percent of copper.

19. The method of claim **14**, wherein the first braze material comprises 40 to 60 weight percent palladium.

* * * * *

EXHIBIT G

US007665552B2

(12) **United States Patent**
Hall et al.

(10) **Patent No.: US 7,665,552 B2**
(45) **Date of Patent: Feb. 23, 2010**

(54) **SUPERHARD INSERT WITH AN INTERFACE**

(76) Inventors: **David R. Hall**, 2185 S. Larsen Pkwy., Provo, UT (US) 84606; **Ronald Crockett**, 2185 S. Larsen Pkwy., Provo, UT (US) 84606

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 462 days.

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(22) Filed: **Oct. 26, 2006**

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E21B 10/46 (2006.01)

(52) **U.S. Cl.** **175/426**; 175/420.2

(58) **Field of Classification Search** 175/374, 175/420.2, 426, 428, 434
See application file for complete search history.

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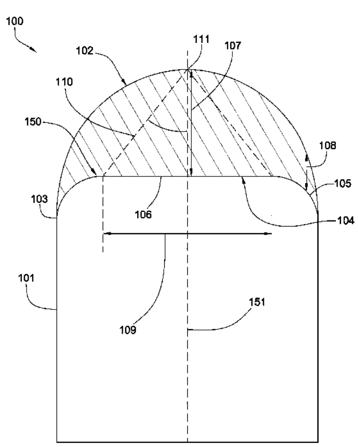
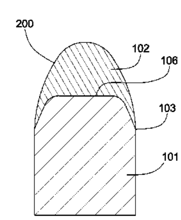
Primary Examiner—Daniel P Stephenson
(74) *Attorney, Agent, or Firm*—Tyson J. Wilde

(57) **ABSTRACT**

In one aspect of the invention, a superhard insert has a carbide substrate bonded to ceramic layer at an interface. The substrate has a generally frusto-conical end at the interface with a tapered portion leading to a flat portion. The central section of the ceramic layer may have a first thickness immediately over the flat portion of the substrate. The peripheral section of the ceramic layer has a second thickness being less than the first thickness covering the tapered portion of the substrate. The ceramic layer may be formed using HPHT technology.

11 Claims, 10 Drawing Sheets





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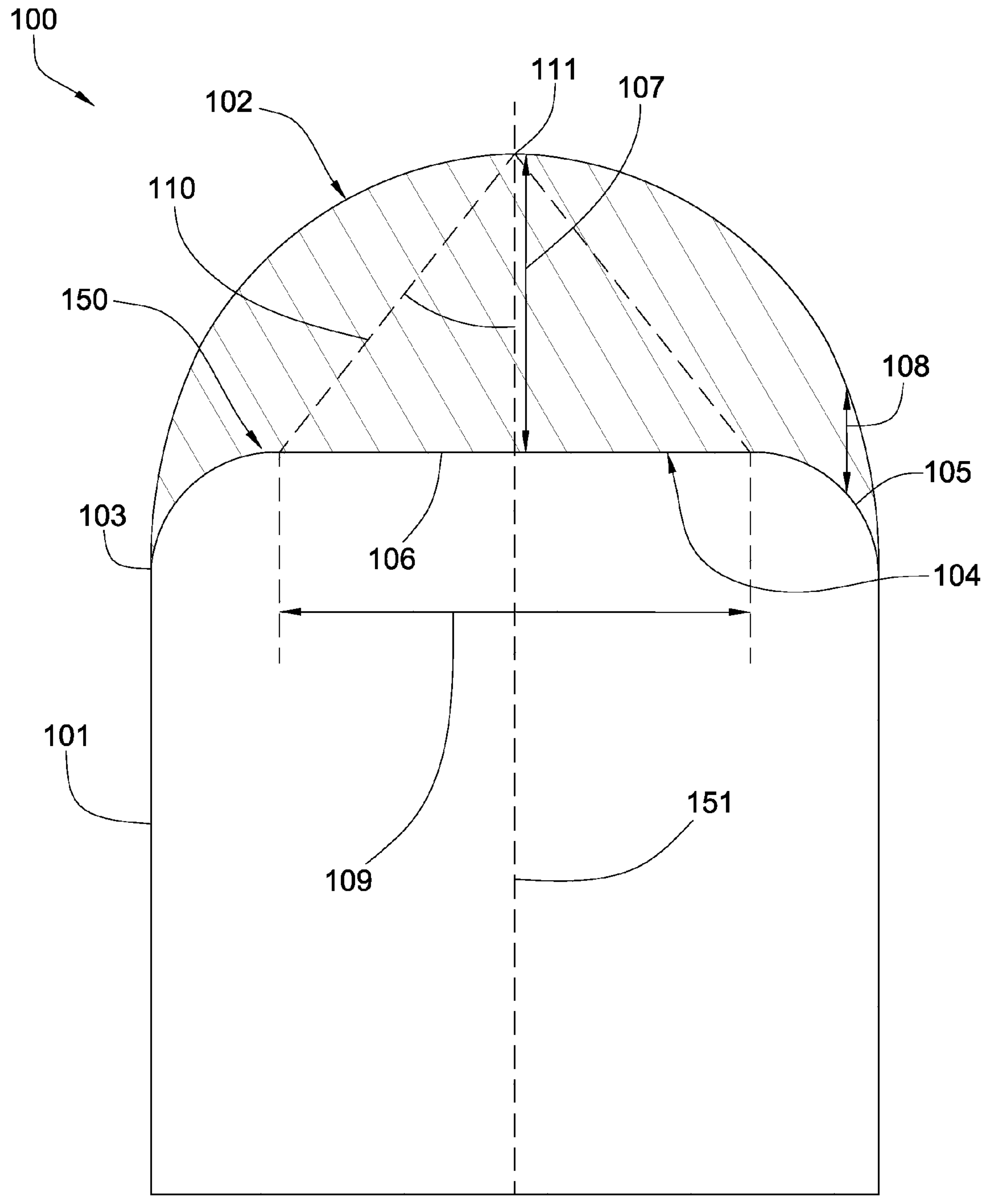

Fig. 1

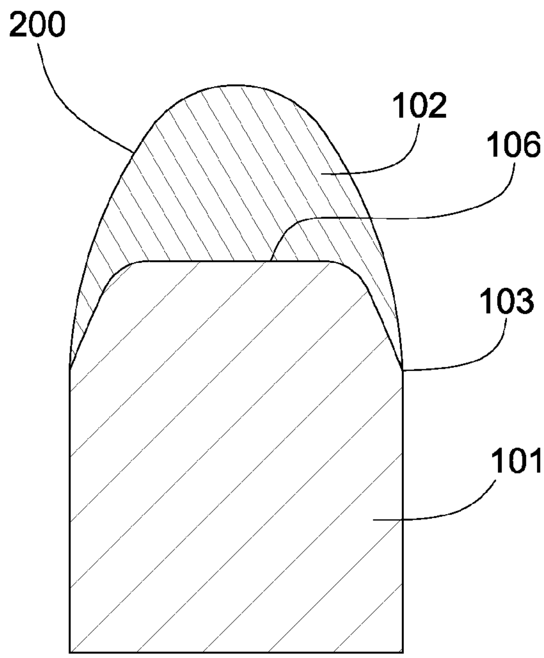

Fig. 2

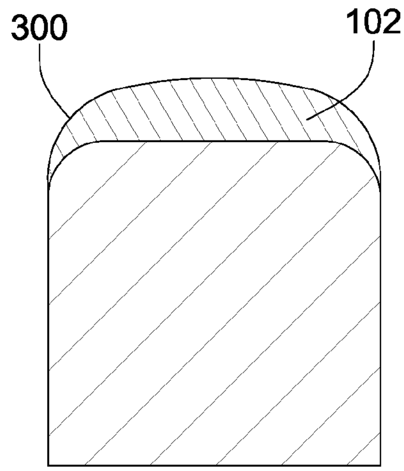

Fig. 3

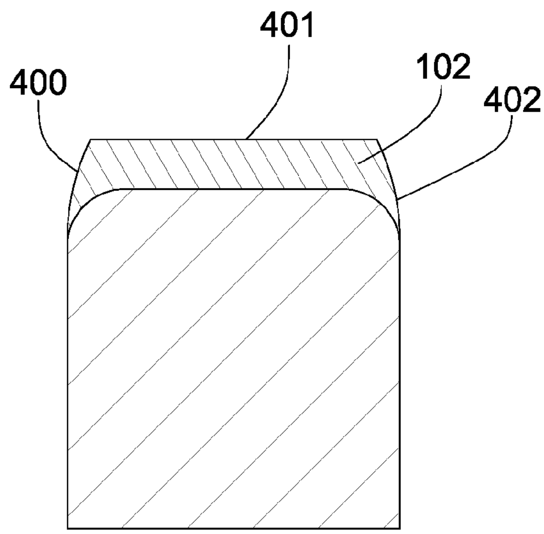

Fig. 4

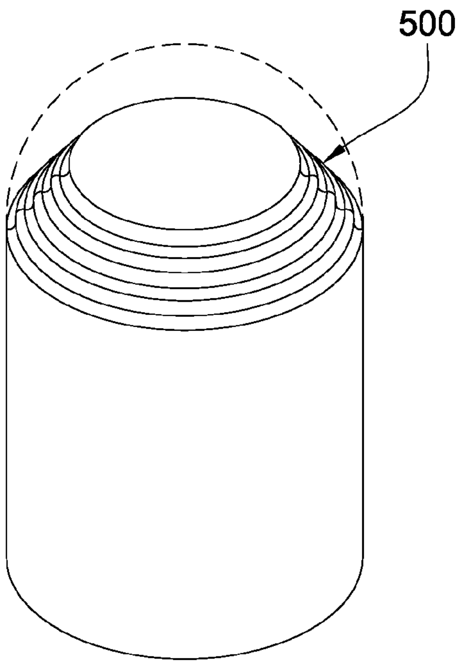

Fig. 5

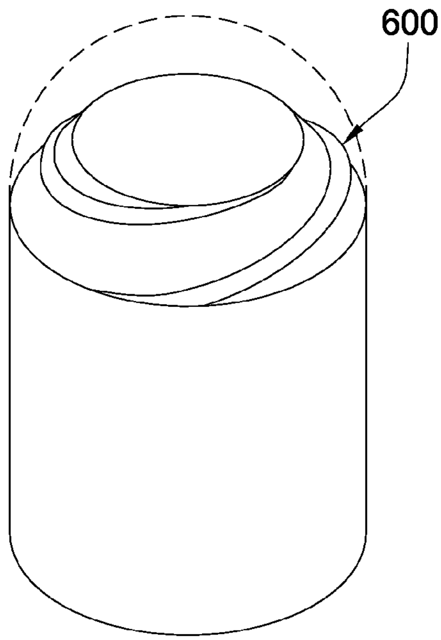

Fig. 6

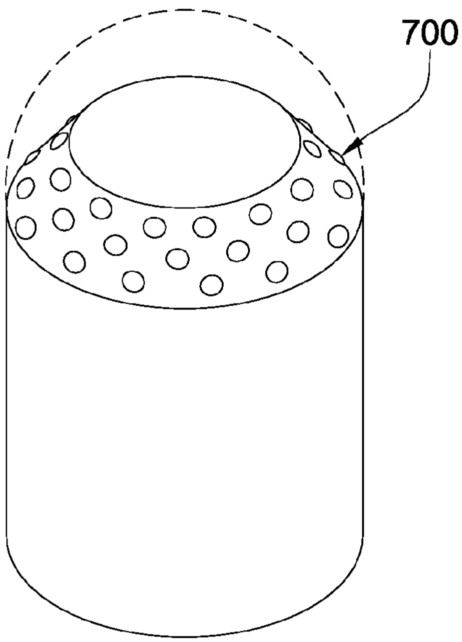

Fig. 7

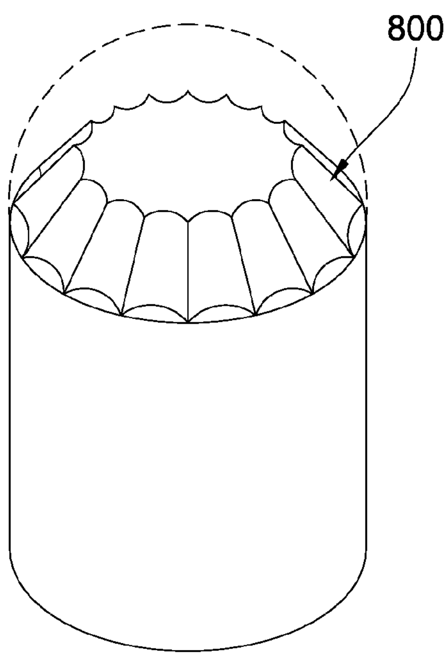

Fig. 8

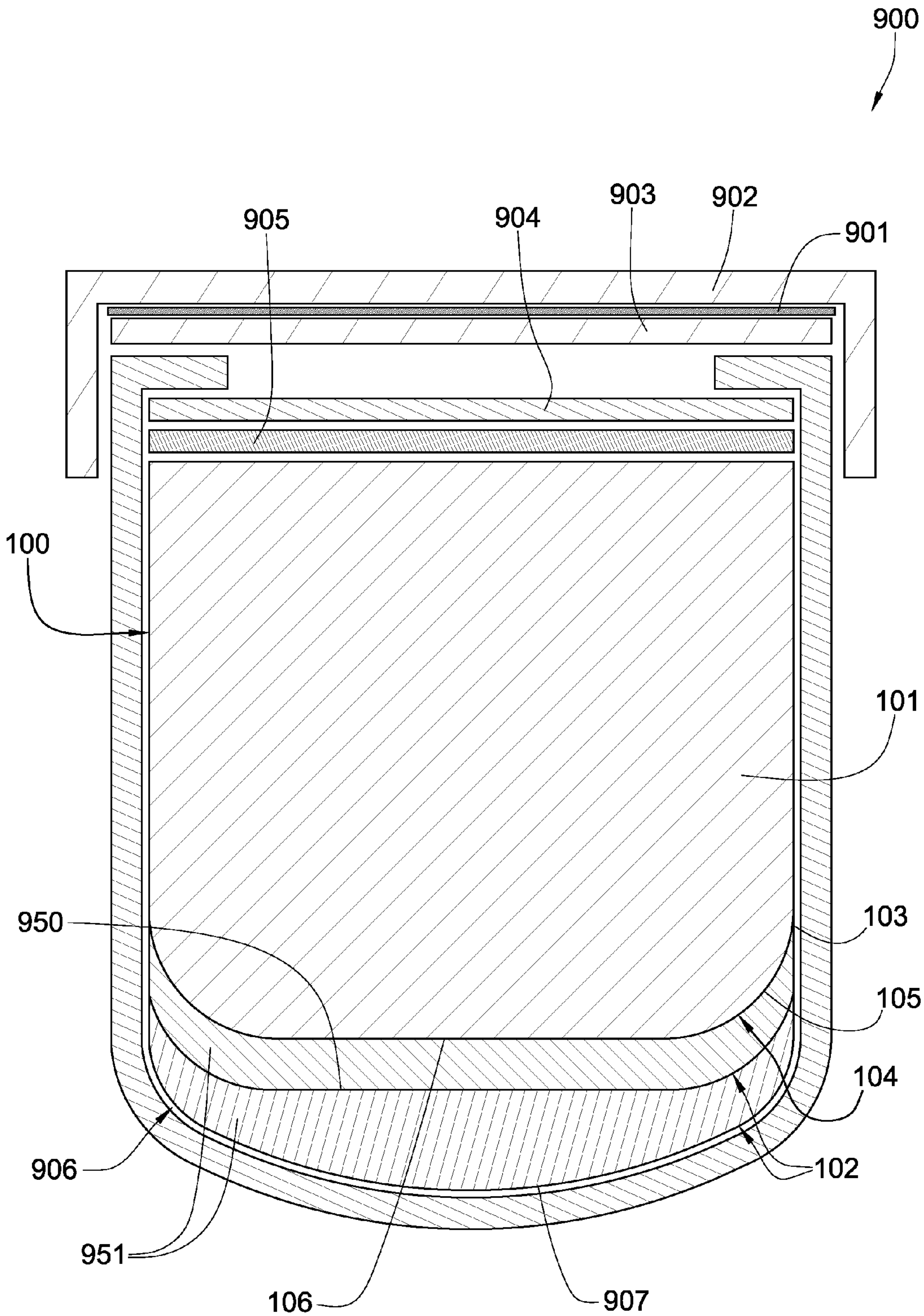
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Fig. 9

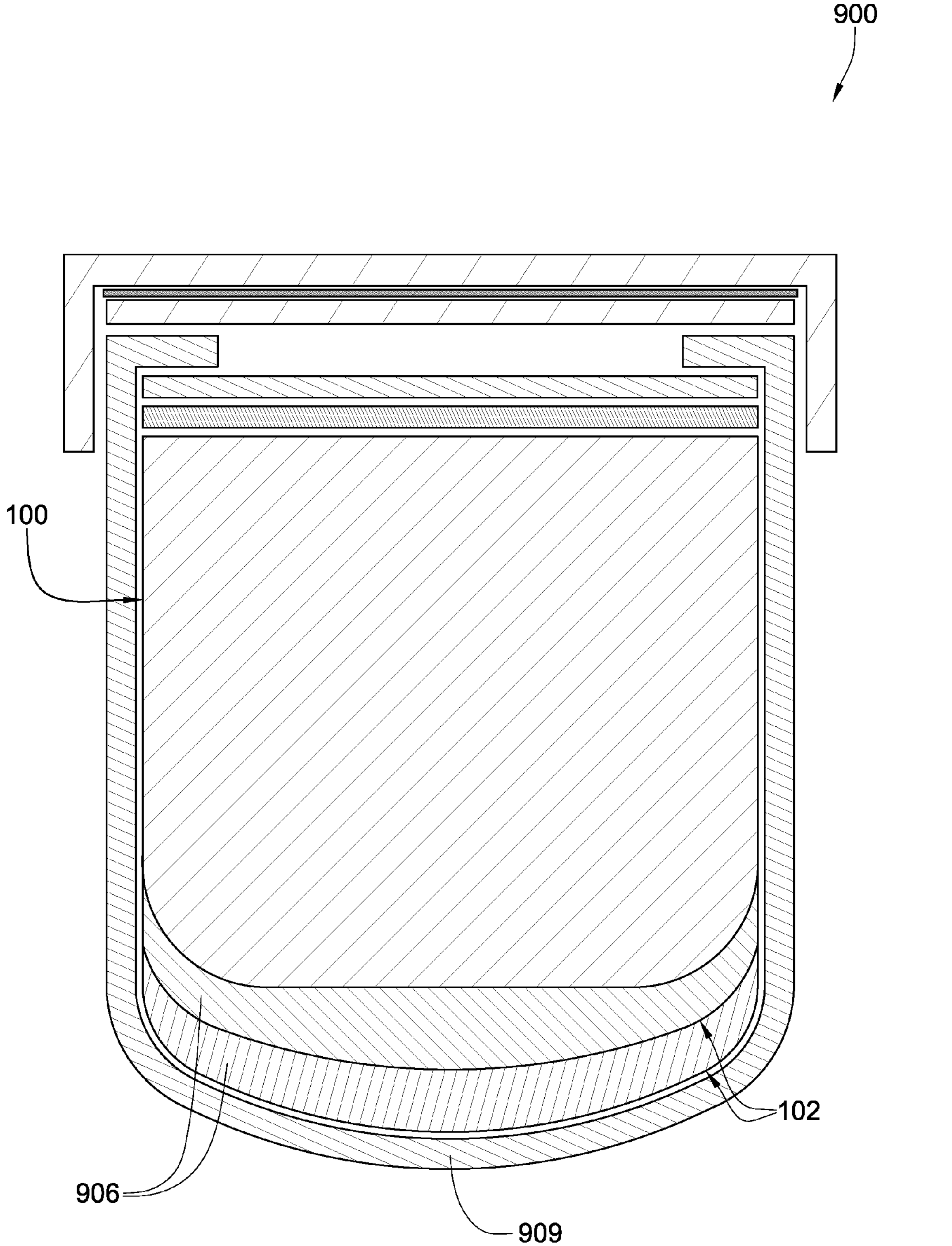

Fig. 10

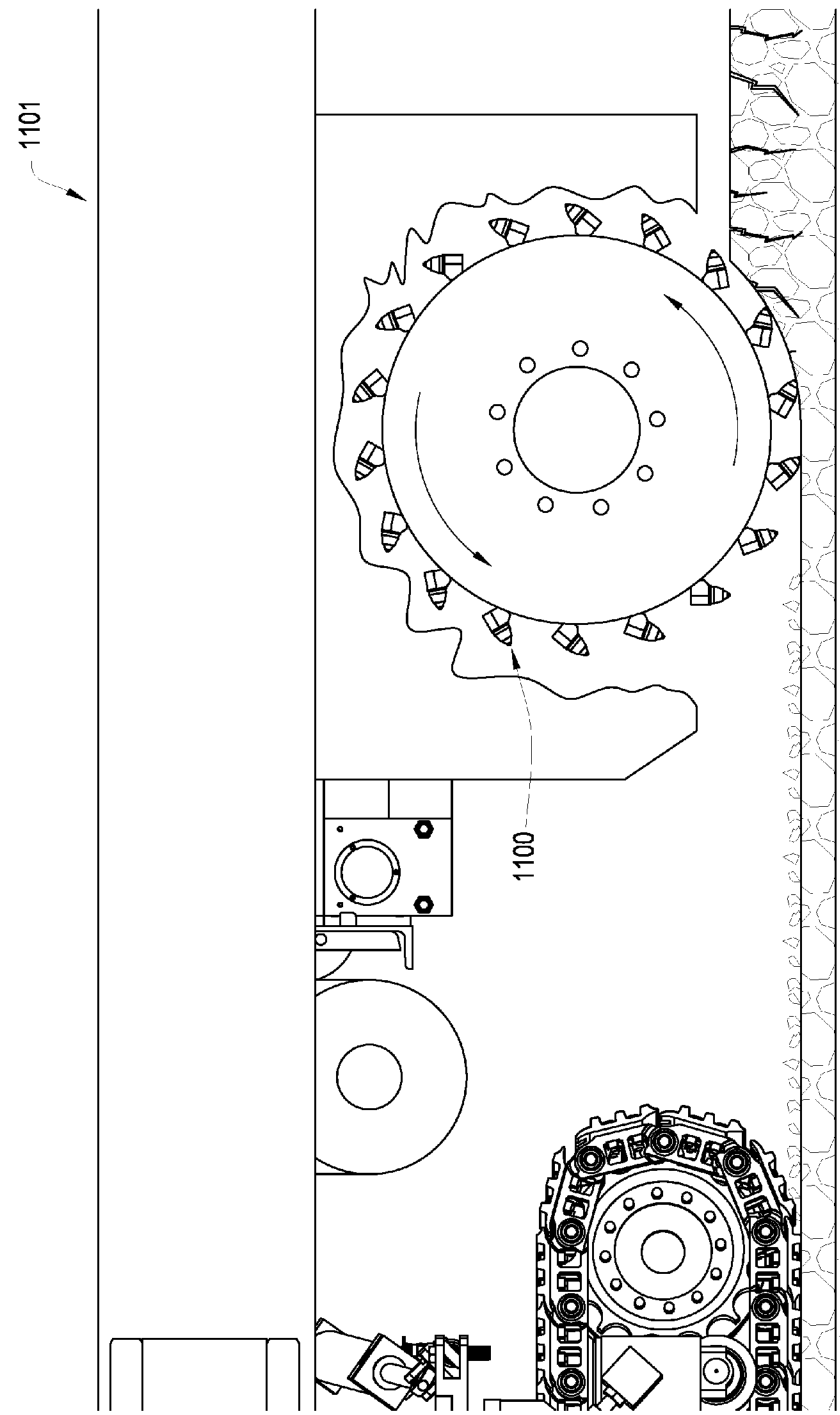

Fig. 11

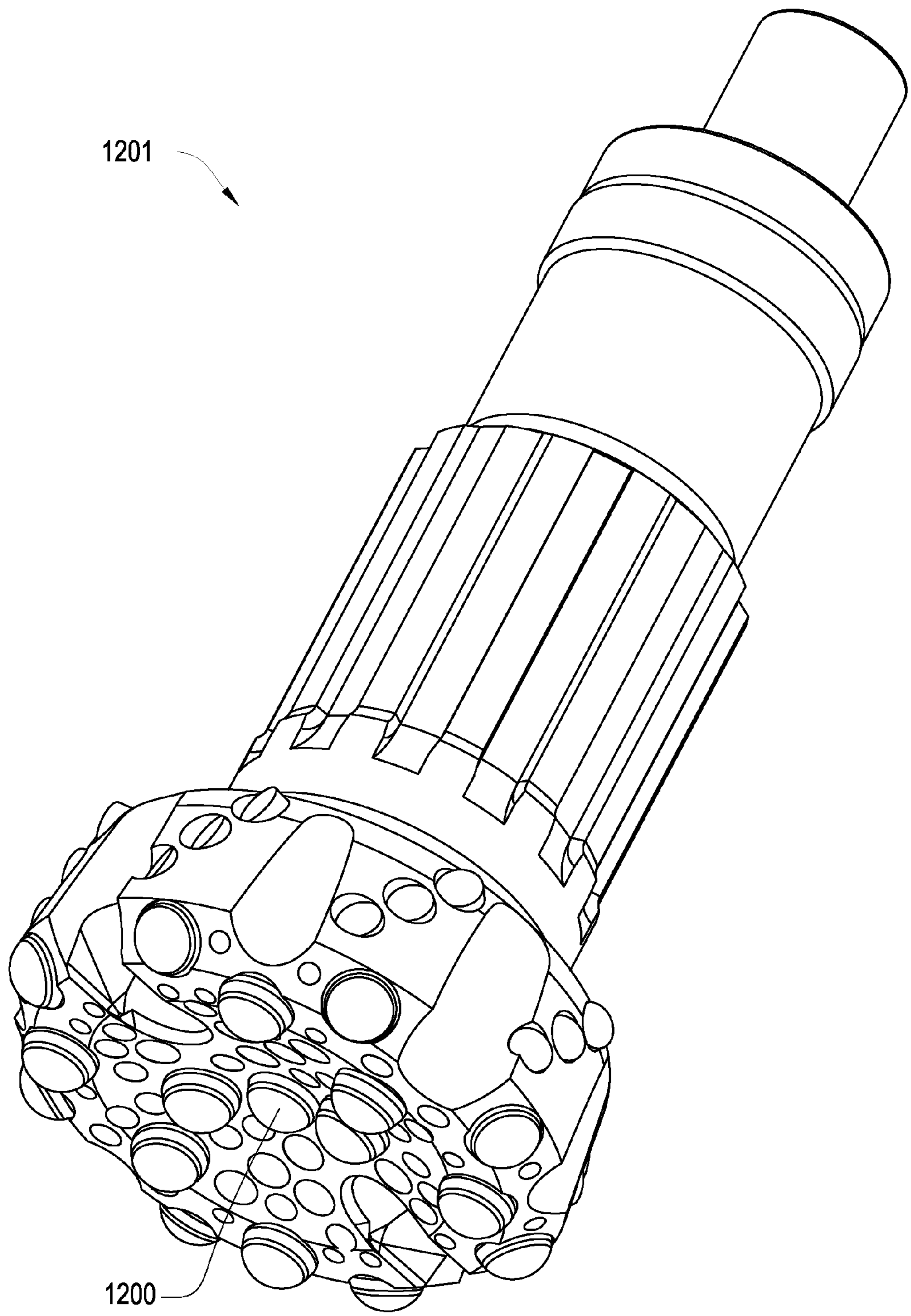

Fig. 12

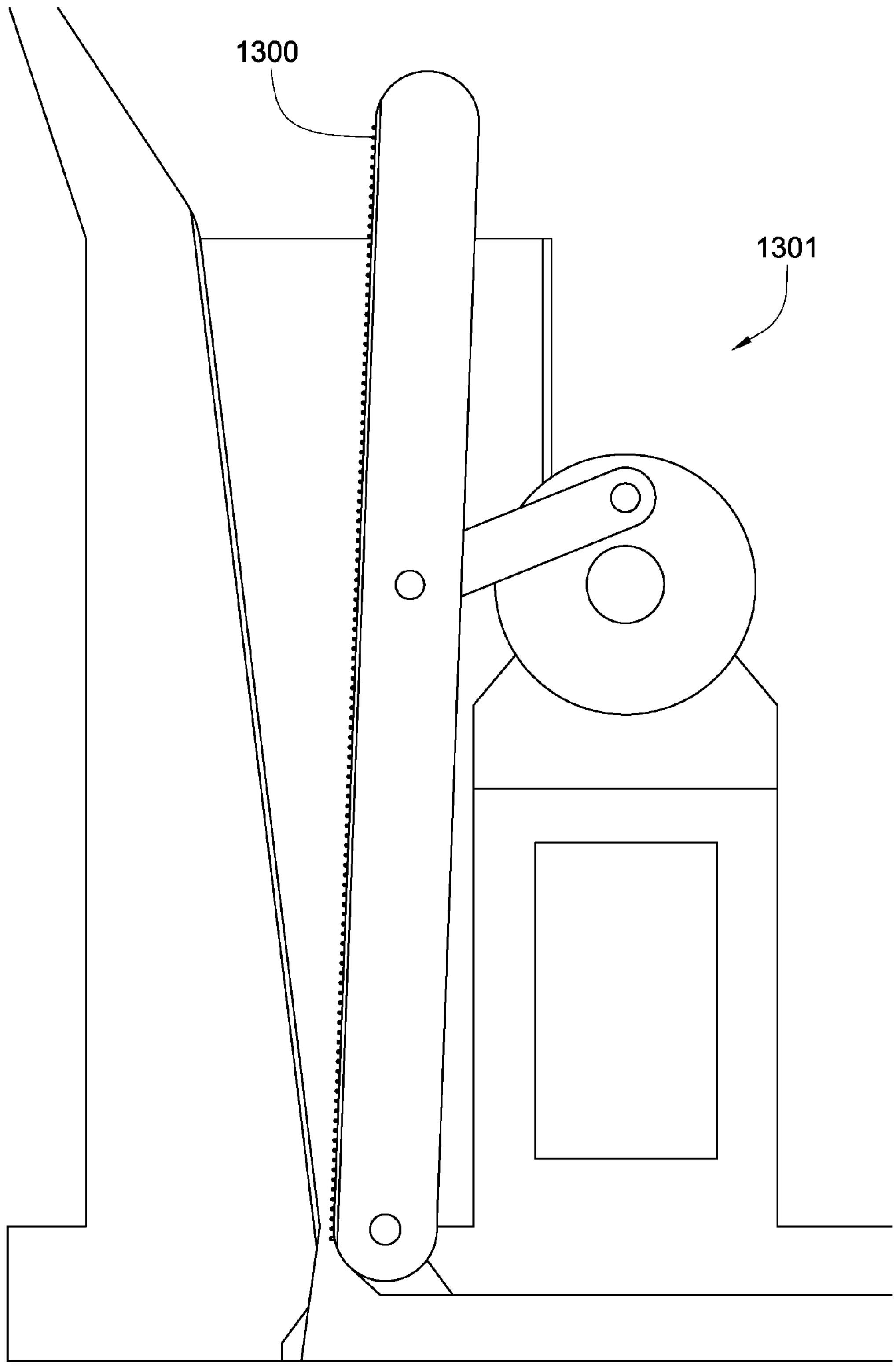

Fig. 13

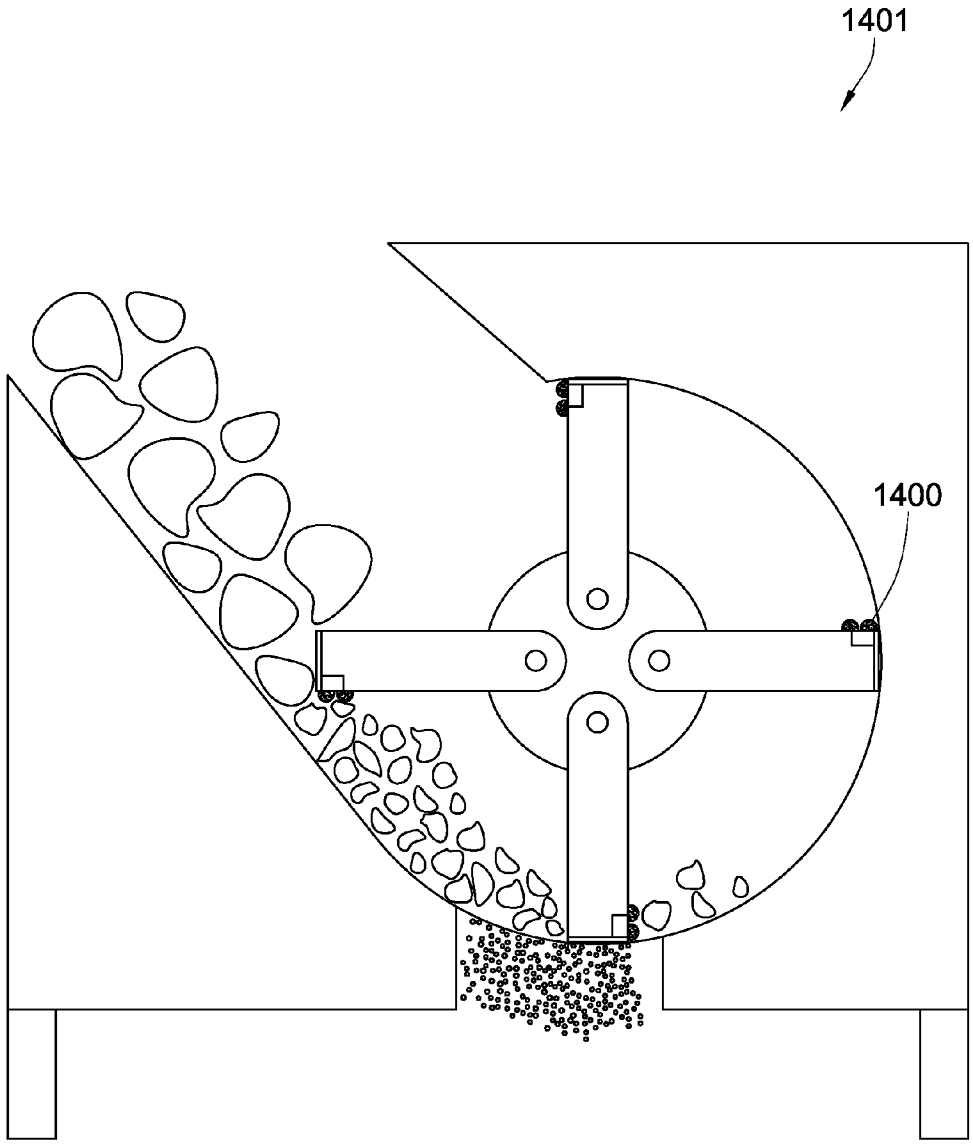

Fig. 14

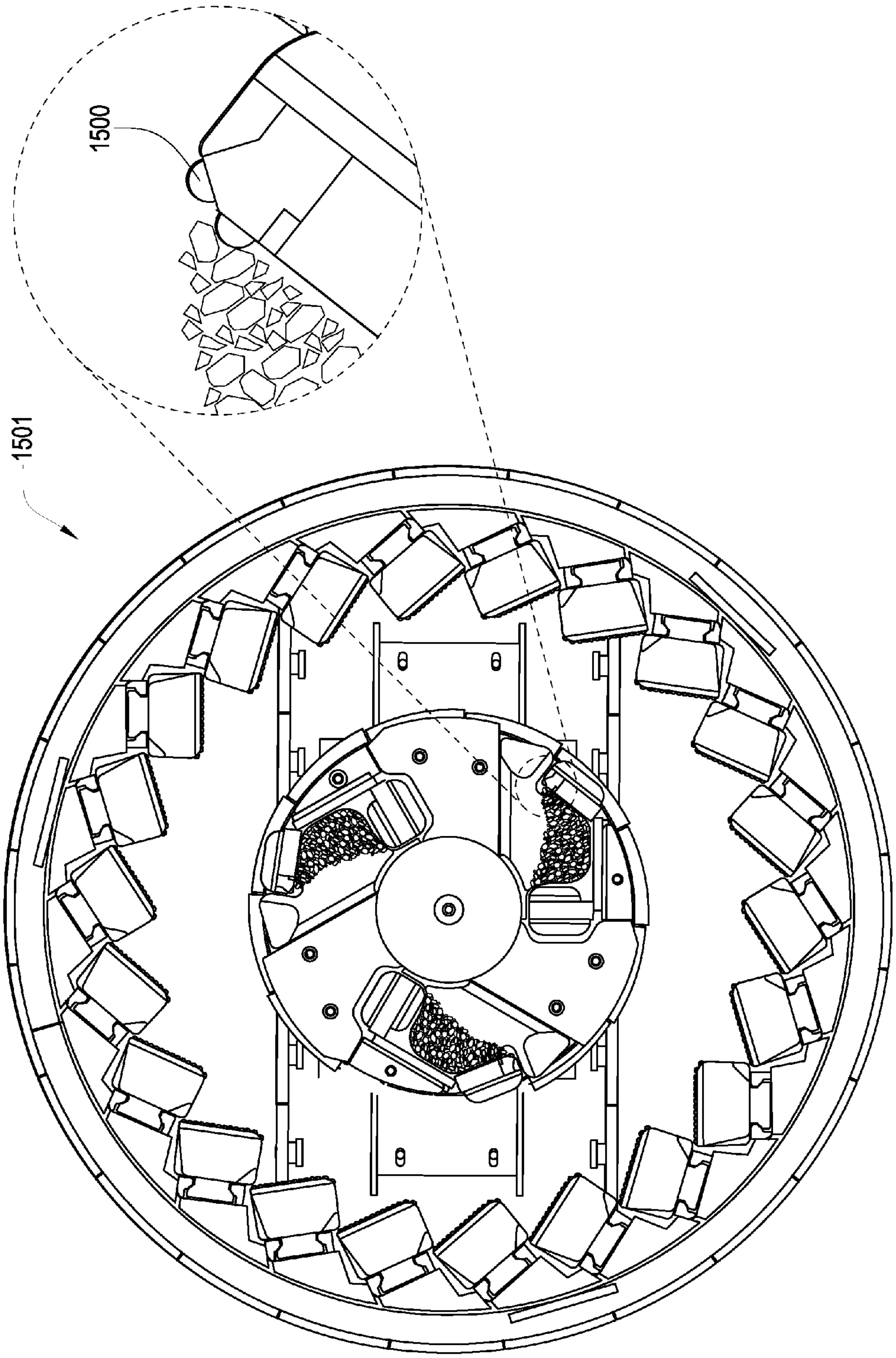

Fig. 15

SUPERHARD INSERT WITH AN INTERFACE

BACKGROUND OF THE INVENTION

The invention relates to an improved cutting element or insert that may be used in machinery such as crushers, picks, grinding mills, roller cone bits, rotary fixed cutter bits, earth boring bits, percussion bits or impact bits, and drag bits. More particularly, the invention relates to inserts comprised of a carbide substrate with a nonplanar interface and an abrasion resistant layer of super hard material affixed thereto using a high pressure high temperature press apparatus. Such inserts typically comprise a super hard material layer or layers formed under high temperature and pressure conditions, usually in a press apparatus designed to create such conditions, cemented to a carbide substrate containing a metal binder or catalyst such as cobalt. The substrate is often softer than the super hard material to which it is bound. Some examples of super hard materials that high temperature high pressure (HPHT) presses may produce and sinter include cemented ceramics, diamond, polycrystalline diamond, and cubic boron nitride. A cutting element or insert is normally fabricated by placing a cemented carbide substrate into a container or cartridge with a layer of diamond crystals or grains loaded into the cartridge adjacent one face of the substrate. A number of such cartridges are typically loaded into a reaction cell and placed in the high pressure high temperature press apparatus. The substrates and adjacent diamond crystal layers are then compressed under HPHT conditions which promotes a sintering of the diamond grains to form the polycrystalline diamond structure. As a result, the diamond grains become mutually bonded to form a diamond layer over the substrate face, which is also bonded to the substrate face.

Such inserts are often subjected to intense forces, torques, vibration, high temperatures and temperature differentials during operation. As a result, stresses within the structure may begin to form. Drill bits for example may exhibit stresses aggravated by drilling anomalies during well boring operations such as bit whirl or spalling often resulting in delamination or fracture of the abrasive layer or substrate thereby reducing or eliminating the cutting elements efficacy and decreasing overall drill bit wear life. The ceramic layer of an insert sometimes delaminates from the carbide substrate after the sintering process and/or during percussive and abrasive use. Damage typically found in percussive and drag bits is a result of shear failures, although non-shear modes of failure are not uncommon. The interface between the ceramic layer and substrate is particularly susceptible to nonshear failure modes.

U.S. Pat. No. 5,544,713 by Dennis, which is herein incorporated by reference for all that it contains, discloses a cutting element which has a metal carbide stud having a conic tip formed with a reduced diameter hemispherical outer tip end portion of said metal carbide stud.

U.S. Pat. No. 6,196,340 by Jensen, which is herein incorporated by reference for all that it contains, discloses a cutting element insert provided for use with drills used in the drilling and boring through of subterranean formations.

U.S. Pat. No. 6,258,139 by Jensen, which is herein incorporated by reference for all that it contains, discloses a cutting element, insert or compact which is provided for use with drills used in drilling and boring subterranean formation or in machining of metal, composites or wood-working.

U.S. Pat. No. 6,260,639 by Yong et al., which is herein incorporated by reference for all that it contains, discloses a cutter element for use in a drill bit, having a substrate comprising a grip portion and an extension and at least a cutting layer affixed to said substrate.

U.S. Pat. No. 6,408,959 by Bertagnolli et al., which is herein incorporated by reference for all that it contains, discloses a cutting element, insert or compact which is provided for use with drills used in the drilling and boring of subterranean formations.

U.S. Pat. No. 6,484,826 by Anderson et al., which is herein incorporated by reference for all that it contains, discloses enhanced inserts formed having a cylindrical grip and a protrusion extending from the grip.

U.S. Pat. No. 5,848,657 by Flood et al, which is herein incorporated by reference for all that it contains, discloses domed polycrystalline diamond cutting element wherein a hemispherical diamond layer is bonded to a tungsten carbide substrate, commonly referred to as a tungsten carbide stud. Broadly, the inventive cutting element includes a metal carbide stud having a proximal end adapted to be placed into a drill bit and a distal end portion. A layer of cutting polycrystalline abrasive material disposed over said distal end portion such that an annulus of metal carbide adjacent and above said drill bit is not covered by said abrasive material layer.

BRIEF SUMMARY OF THE INVENTION

The present invention includes an improved superhard insert comprising a carbide substrate bonded to ceramic layer at an interface. In one aspect of the invention the substrate may comprise a generally frusto-conical end at the interface with a tapered portion leading to a flat portion. A central section of the ceramic layer may comprise a first thickness immediately over the flat portion of the substrate. The peripheral section of the ceramic layer may comprise a second thickness being less than the first thickness covering the tapered portion of the substrate. The flat portion of the interface may serve to substantially diminish the effects of failure initiation points in the insert. The substrate may further comprise a material selected from the group consisting of cemented metal-carbide, tungsten carbide, silicon carbide, and titanium carbide. The ceramic layer may be bonded to the substrate using HPHT technology that incorporates a method using a container comprising a sealant that is used to substantially remove any contaminants before being placed in a HPHT press apparatus. The ceramic layer may further comprise layers of various diamond or cubic boron nitride grain sizes that are infiltrated with a metal binder that are arranged to improve bonding at the interface and help reduce delamination in the ceramic layer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross sectional diagram of an embodiment of an insert depicting a ceramic layer bonded to a carbide substrate comprising a non-planar interface.

FIG. **2** is a cross sectional diagram of another embodiment depicting a ceramic layer comprising a generally conical tip bonded to a carbide substrate.

FIG. **3** is a cross sectional diagram of another embodiment depicting a ceramic layer comprising a generally flatten tip bonded to a carbide substrate.

FIG. **4** is a cross sectional diagram of another embodiment depicting a ceramic layer comprising a chamfered geometry

FIG. **5** is a perspective diagram of an embodiment depicting an interface comprising a ribbed annular tapered portion.

FIG. **6** is a perspective diagram of an embodiment depicting an interface comprising a spiral ribbed tapered portion.

FIG. **7** is a perspective diagram of an embodiment depicting an interface comprising a tapered portion comprising a plurality of protuberances.

FIG. **8** is a perspective diagram of an embodiment depicting an interface comprising a corrugated tapered portion.

FIG. **9** is a cross sectional diagram of a container of forming an insert depicting the ceramic layer and carbide substrate disposed within a HPHT container.

FIG. **10** is a cross sectional diagram of another container of forming an insert depicting the ceramic layer and carbide substrate disposed within a HPHT container.

FIG. **11** is a perspective diagram of another embodiment of an insert incorporated in an asphalt milling machine.

FIG. **12** is a perspective diagram of another embodiment of an insert incorporated in a percussion drill bit.

FIG. **13** is a perspective diagram of another embodiment of an insert incorporated in a jaw crusher.

FIG. **14** is a perspective diagram of another embodiment of an insert incorporated in a hammer mill.

FIG. **15** is a perspective diagram of another embodiment of an insert incorporated in a vertical shaft impactor.

DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

FIG. **1** discloses a superhard insert **100** comprising a carbide substrate **101** bonded to ceramic layer **102** at an interface **103**. In one aspect of the invention the carbide substrate **101** may comprise a generally frusto-conical end **104** at the interface **103** with a tapered portion **105** leading to a flat portion **106** comprised of a material selected from the group consisting of cemented metal-carbide, tungsten carbide, silicon carbide, and titanium carbide. In another aspect of the invention the ceramic layer **102** may comprise of cubic boron nitride or diamond with a hardness of at least 4000 HV which is utilized to improve the overall durability of the insert **100**. The central section of the ceramic layer **102** may comprise a first thickness **107** between 0.125 and 0.300 inches immediately over the flat portion **106** of the carbide substrate **101** while the peripheral section of the ceramic layer **102** may comprise a second thickness **108** which is less than the first thickness **107** over the tapered portion **105** of the carbide substrate **101**. Preferably, the ceramic layer is a monolayer, but in other embodiments, the ceramic layer may comprise a plurality of sublayers.

A significant feature of this invention is the flat portion **106** of the carbide substrate **102** which may effectively redistribute the load stresses across the interface **103** of the carbide substrate **101**. The flat portion **106** may comprise a diameter **109** measuring 66% to 133% the first thickness **107** of the ceramic layer **102**. In some embodiments, the flat portion **106** may comprise a diameter **109** measuring 75% to 125% the first thickness **107** of the ceramic layer **102**. In other embodiments the first thickness is basically equal to the diameter. In some embodiments, a circumference **150** (or a perimeter) of the flat portion **106** may be chosen by placing the circumference **150** so that it intersects generally at an imaginary line **110** which line **110** intersects the central axis **151** of the insert at the apex **111** and forms a generally 45 degrees angle with the central axis **151**. In other embodiments, the imaginary line **110** falls within the area of the flat portion **106** generally encompassed by the circumference **150**. The flat portion **106** may provide a larger surface area and help to diffuse load stresses on the carbide substrate **101**. This may be particularly advantageous in helping to improve the overall durability of the insert **100** especially where the concentration of the load stresses are focused at the apex **111** of the ceramic layer **102** and subsequently transferred to the carbide substrate **101**. As a result the effective redistribution of such load stresses may assist to further reduce spalling or delamination of the ceramic layer **102**.

It is believed that a load applied to the apex **111** of the ceramic layer **102** will induce a shock wave generally traveling at a 45 degrees in basically all azimuthal directions from the impact of the load. Preferably, the impact occurs proximate the apex **111** and therefore the shock wave may travel basically along the imaginary line **110**. Preferably, the shock wave reaches the interface between the ceramic layer and the substrate some wherein in the flat portion so that the shock wave may be loaded to a flat surface rather than on a point of a curved surface. The first thickness' relationship to the diameter of the flat may be critical. If the first thickness is too large than the shock wave may not hit the flat portion. On the other hand if the first thickness is too small, then the shock wave may not have enough room to distribute across the interface **106** focusing too much of the shock wave to localized areas on the flat. If the focused shock wave is too high the bond at the interface may become compromised.

FIG. **2** discloses another embodiment of the current invention depicting the ceramic layer **102** comprising a generally conical geometry **200**. The generally conical geometry **200** may comprise a generally thicker ceramic layer **102** directly over the flat portion **106** of the interface **103** between the carbide substrate **101**. FIG. **3** discloses another embodiment depicting the ceramic layer **102** comprising a generally slight convex geometry **300** while FIG. **4** discloses an embodiment depicting the ceramic layer **102** comprising a chamfered geometry **400** comprising a generally flat top portion **401** with edges **402** that angles between 90-179 degrees with the flat top.

FIGS. **5-8** depict various configurations of the tapered portion **105** of the interface **103**. The tapered portion **105** may comprise a ribbed annular portion **500**, a spiral ribbed portion **600**, a plurality of protuberances **700** disposed in alternating rows, or a plurality of vertically disposed nodules **800**. In some embodiments the various configurations of the tapered portion **105** may assist to provide improved bonding between the interface **103** and help to reduce fragmentation or separation of the carbide substrate **101** from the ceramic layer **102** especially when the insert **100** is subjected to anomalies during operation that may cause detrimental jarring effects.

FIG. **9** discloses another embodiment of the current invention depicting a method of forming the insert **100**. U.S. patent Ser. No. 11/469,229 discloses an assembly for HPHT processing which is herein incorporate by reference for all that it contains pertaining to an improved assembly for HPHT processing having a can with an opening and a mixture disposed within the opening. FIG. **9** depicts a container **900** adapted to make the present invention. The container **900** may be comprised of metal or a metal alloy also have a sealant material **901** that may be disposed intermediate a cap **902** and a first lid **903** also comprising a second lid **904** and a sealant barrier **905** which may be used to form the ceramic layer **102** or layers of the insert **100** utilizing HPHT technology. A preformed carbide substrate **101** comprising a generally frusto-conical end **104** at the interface **103** with a tapered portion **105** leading to a flat portion **106** may be infused with a metal binder material selected from the group consisting of cobalt, titanium, tantalum, nickel, aluminum, niobium, iron, gold, silver zinc, ruthenium, rhodium, palladium, chromium, manganese, tungsten, mixtures thereof, alloys thereof, and combinations thereof may be disposed within the container **900** adjacent and above a ceramic mixture **906** which is disposed towards the base of the container **900**. The ceramic mixture **906** may comprise

cubic boron nitride or diamond that is arranged in sub layers **951** comprised of different diamond grains having smaller or larger sizes ranging between 0.5 and 300 microns. The sub layers **951** may be arranged substantially proportionate to the flat portion **103** of the carbide substrate **101** such that the sub layers **951** are preformed to have substantially flat portion **950**. In some embodiments the smaller diamond grains may be disposed towards the upper portion of the ceramic layer **102** and help to provide a generally harder ceramic surface. A harder surface may be advantageous in applications such as drill bits where bit wear on the inserts is critical in providing improved rates of penetration. The larger diamond grains may be disposed closer to the carbide substrate **101** and help to provide better elasticity in the ceramic layer **102**. Better elasticity may reduce delamination or spalling of the ceramic layer **102** at the interface **103**, especially as the carbide substrate **101** contracts when cooling after the container **900** is later removed from the HPHT press (not shown). The container **900** may comprise a geometry comprising a conical geometry, a hemispherical geometry, rounded geometry, a domed geometry, a chamfered geometry, or combinations thereof that forms the surface **907** of the ceramic layer **102** that conforms to the geometry of the container **900**.

A sealant material **901** comprising a material selected from the group consisting of a stop off compound, a solder/braze stop, a mask, a tape, a plate, and sealant flow control, or a combination thereof may be disposed at the opposite end **910**. The container **900** and contents may then be heated to a cleansing temperature between 800° C. and 1040° C. for a first period of time between 15 and 60 minutes, which may allow the ceramic mixture **901** to become substantially free of contaminants. The temperature may then be increased to a sealing temperature between 1000° C. and 1200° C. for another 2 and 25 minutes to melt the sealant material **901** and seal the container **900** and the substantially free ceramic mix within it before placing in the HPHT press (not shown).

While in the press under the HPHT conditions, the metal binder material may infiltrate from the carbide substrate **101** into the ceramic layer **102** which may further assist to promote bonding at the interface **103**. In some embodiments the infiltrated metal binder material may comprise a greater concentration adjacent the interface **103** which gradually diminishes through the remainder of the ceramic layer **102**. The infiltrated metal binder material may also assist in providing elasticity in the ceramic layer **102** at the interface **103** and help to further reduce delamination from the carbide substrate **101** during the cooling process after being formed in a HPHT press. FIG. **10** discloses another embodiment of the current invention depicting an alternative method of forming the insert **100** in a container **900** utilizing HPHT technology wherein the ceramic layer **102** may comprise at least one layer of ceramic mixture **906** which may also comprised of diamond having grains of different sizes that conform to the geometry of the base portion **909** of the container **900**.

FIGS. **11-14** disclose the current invention depicting the insert within various embodiments as a pick **1100** in an asphalt milling machine **1101**, an insert **1200** in a percussion drill bit **1201**, an insert **1300** in a jaw crusher **1301**, an insert **1400** in a hammer mill **1401**, an insert **1500** in an impellor blade in a vertical shaft impactor **1501**. In yet other embodiments the insert may also be attached to a mining pick, trenching pick, a drill bit, a shear bit, a roller one bit, a milling machine, a cone crusher, a chisel or combinations thereof.

Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

What is claimed is:

1. A superhard insert, comprising:

a carbide substrate bonded to a ceramic mono layer at an interface;

the ceramic monolayer comprises an apex at the central axis of the insert;

the substrate comprising a generally frusto-conical end at the interface with a tapered portion leading to a flat portion;

the ceramic layer comprising diamond or cubic boron nitride and a central section immediately above the flat with a first thickness;

the ceramic layer also comprising a peripheral section adjacent and bonded to the tapered portion of the substrate, the peripheral section comprising a second thickness which is less than the first thickness; and

the flat portion comprising a diameter less than the first thickness.

2. The insert of claim **1**, wherein the substrate is selected from the group consisting of cemented metal-carbide, tungsten carbide, silicon carbide, and titanium carbide.

3. The insert of claim **1**, wherein a metal binder is infiltrated into the ceramic layer and the metal is selected from the group consisting of cobalt, titanium, tantalum, nickel, aluminum, niobium, iron, gold, silver, zinc, ruthenium, rhodium, palladium, chromium, manganese, tungsten, mixtures thereof, alloys thereof, and combinations thereof.

4. The insert of claim **1**, wherein the first thickness is between 0.125 to 0.300 inches.

5. The insert of claim **1**, wherein the tapered portion comprises ribs, protuberances, or nodules.

6. The insert of claim **1**, wherein the ceramic layer comprises a surface with a conical geometry, a hemispherical geometry, rounded geometry, a domed geometry, a chamfered geometry, or combinations thereof.

7. The insert of claim **6**, wherein the ceramic layer comprises a sublayer with a substantially flat portion.

8. The insert of claim **1**, wherein a metal distribution in the ceramic layer comprises a greater concentration adjacent the interface which gradually diminishes through the remainder of the ceramic layer.

9. The insert of claim **1**, wherein the carbide substrate is attached to a pick, mining pick, asphalt pick, trenching pick, drill bit, shear bit, percussion bit, roller cone bit, milling machine, vertical shaft impactor, hammer mill, cone crusher, jaw crusher, chisel, or combinations thereof.

10. The insert of claim **1**, wherein the ceramic layer comprises a plurality of sublayers that conform to the geometry of the surface.

11. The insert of claim **1**, wherein the flat portion comprises a diameter 75 to 99 percent of the first thickness.

* * * * *

EXHIBIT H

US007353893B1

(12) **United States Patent**
Hall et al.

(10) **Patent No.: US 7,353,893 B1**

(45) **Date of Patent: Apr. 8, 2008**

(54) **TOOL WITH A LARGE VOLUME OF A SUPERHARD MATERIAL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/668,254**

(22) Filed: **Jan. 29, 2007**

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/553,338, filed on Oct. 26, 2006.

(51) **Int. Cl.**
E21B 10/36 (2006.01)

(52) **U.S. Cl.** **175/425**; 175/434; 175/435; 299/111

(58) **Field of Classification Search** 175/425, 175/434, 435; 299/110, 111, 113
See application file for complete search history.

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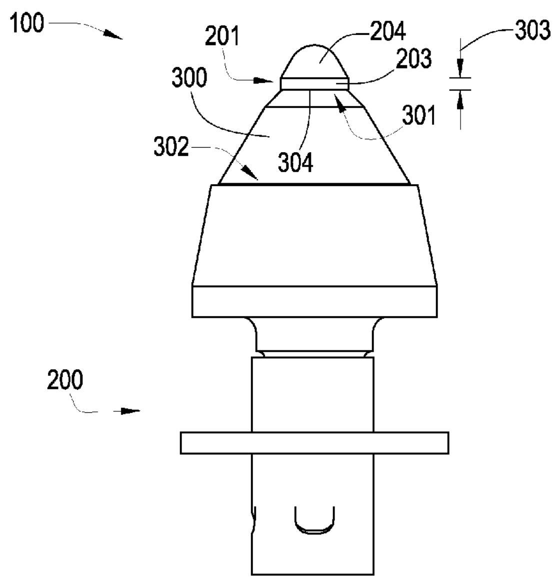
Assistant Examiner—Brad Harcourt
(74) *Attorney, Agent, or Firm*—Tyson J. Wilde

(57) **ABSTRACT**

In one aspect of the invention, a tool has a wear-resistant base suitable for attachment to a driving mechanism and also a hard tip attached to an interfacial surface of the base. The tip has a first cemented metal carbide segment bonded to a superhard material at a non-planar interface. The tip has a height between 4 and 10 mm and also has a curved working surface opposite the interfacial surface. A volume of the superhard material is about 75% to 150% of a volume of the first cemented metal carbide segment.

19 Claims, 10 Drawing Sheets



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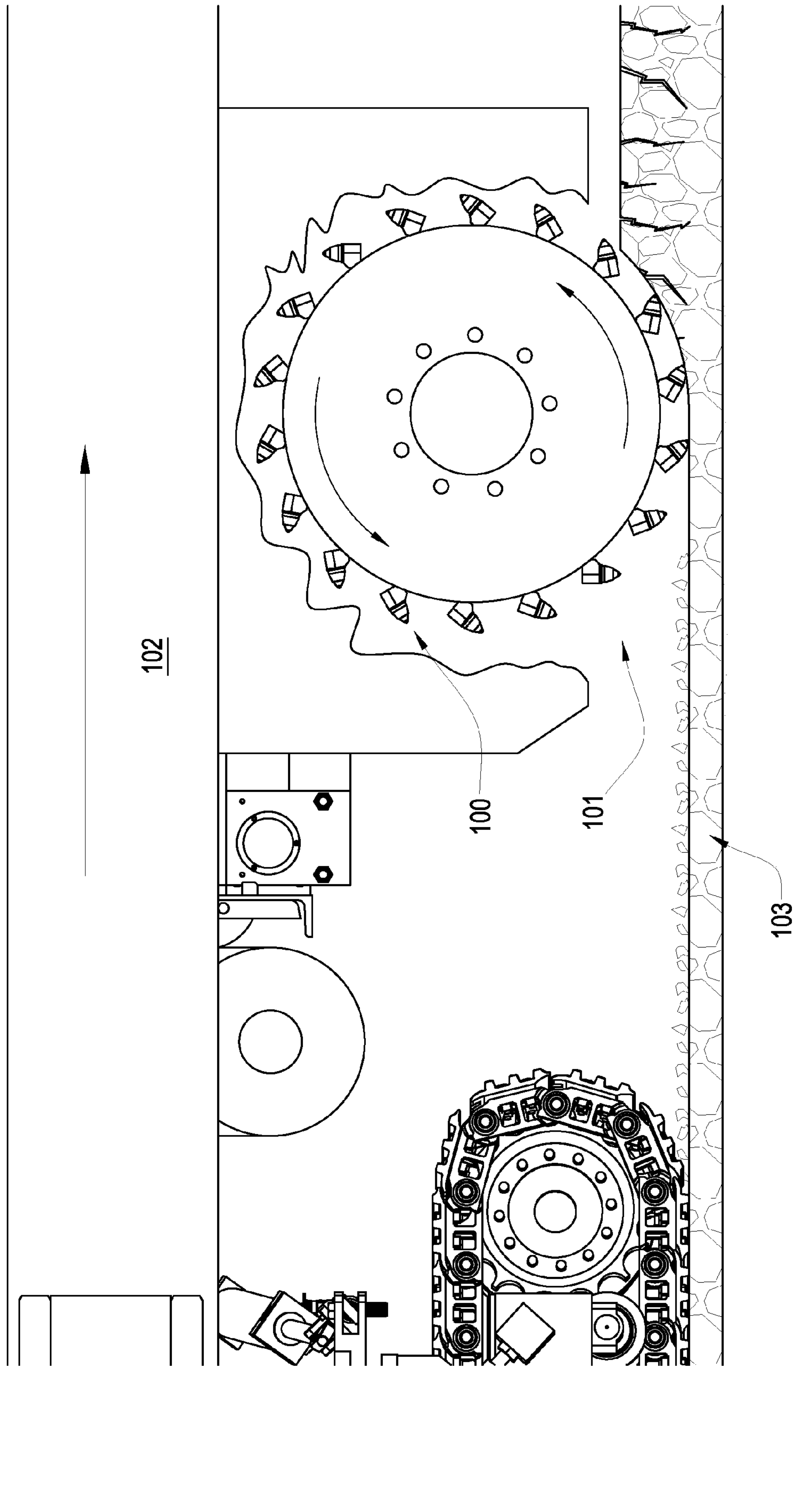

Fig. 1

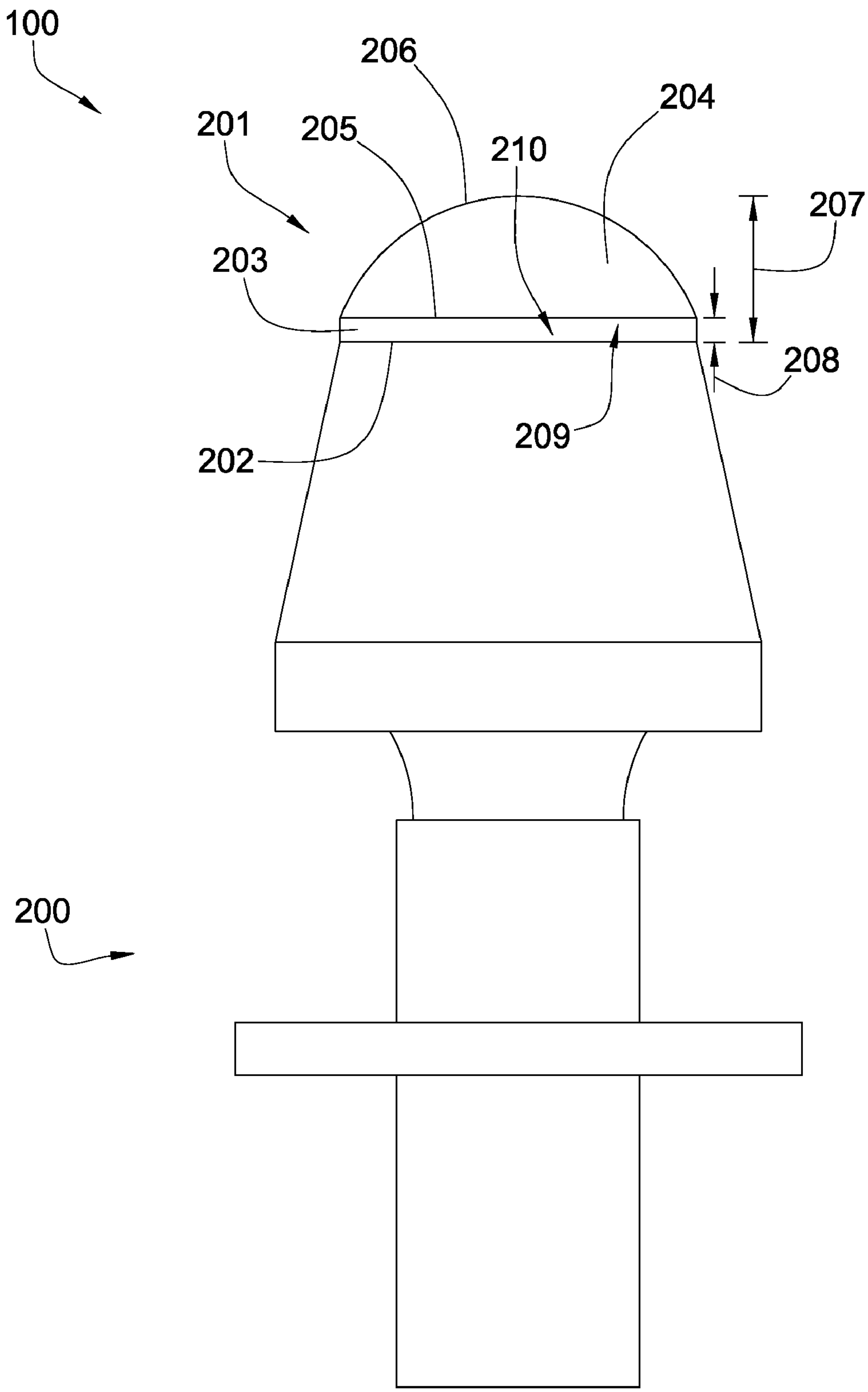

Fig. 2

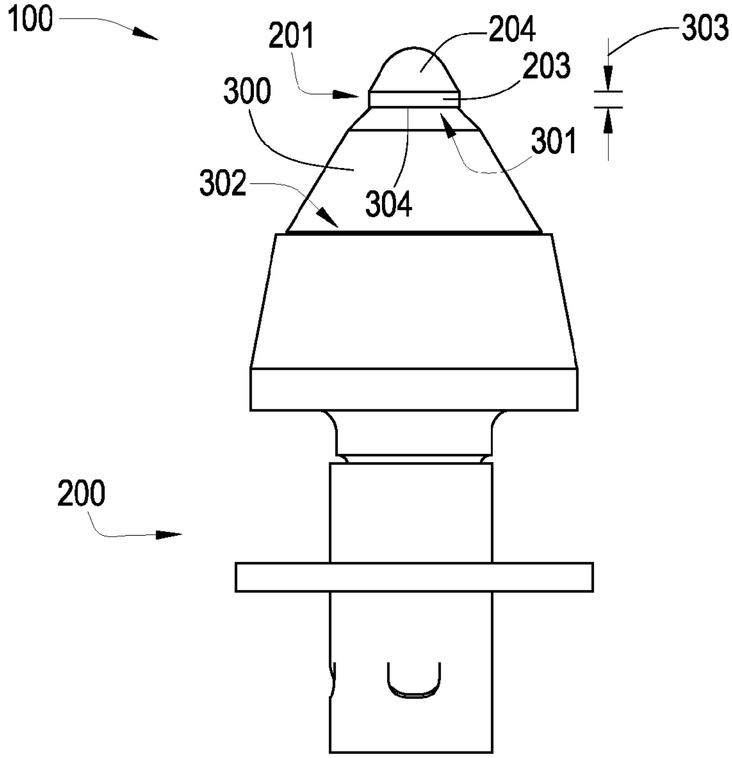

Fig. 3

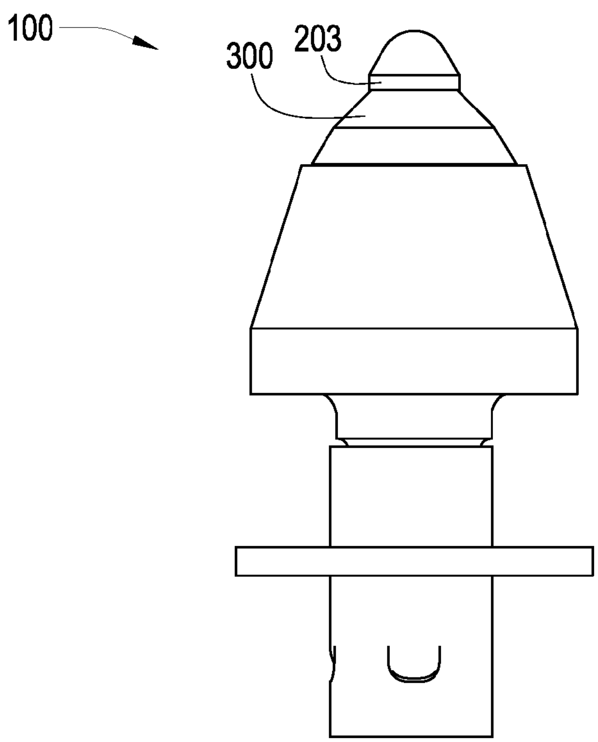

Fig. 4

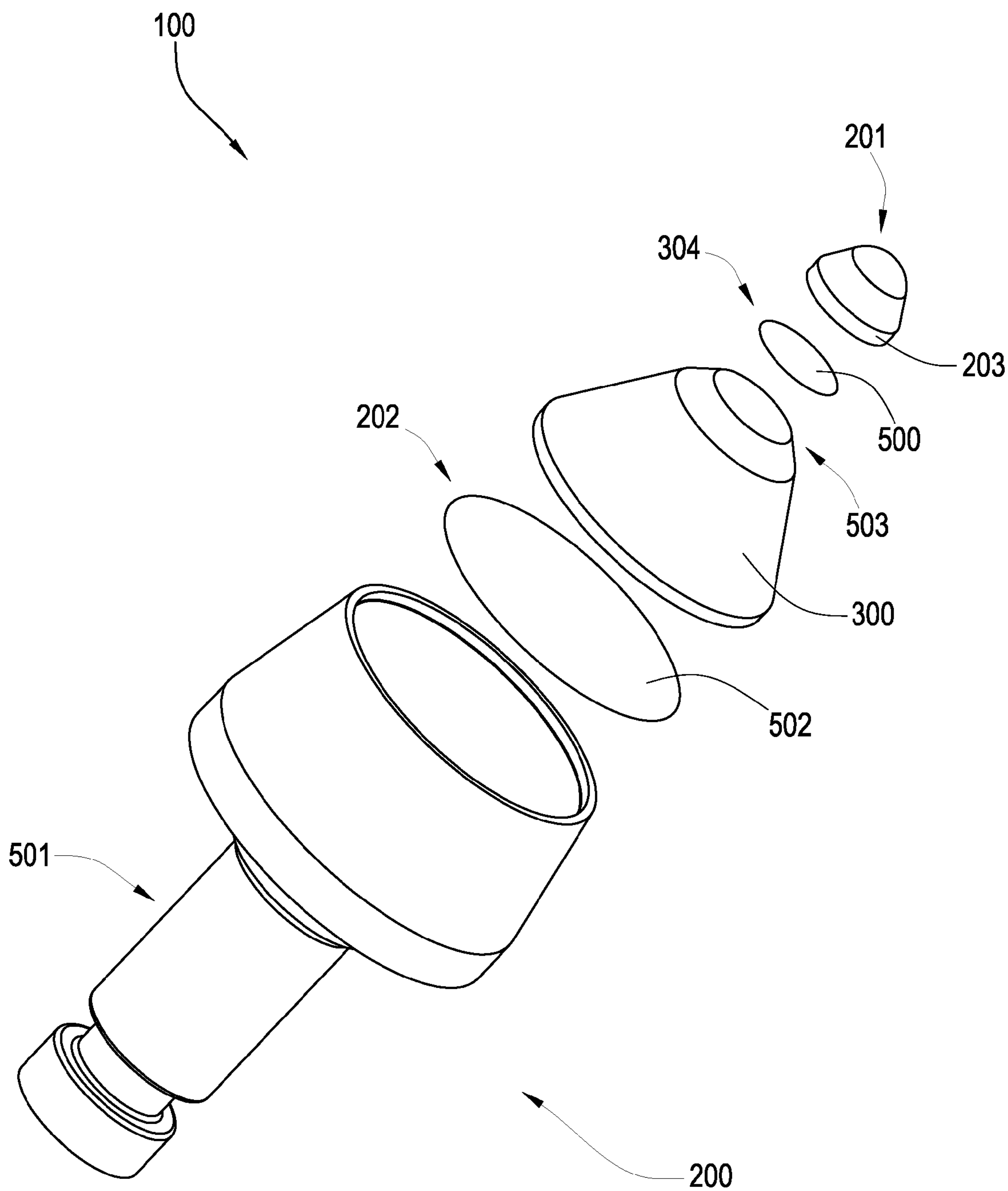

Fig. 5

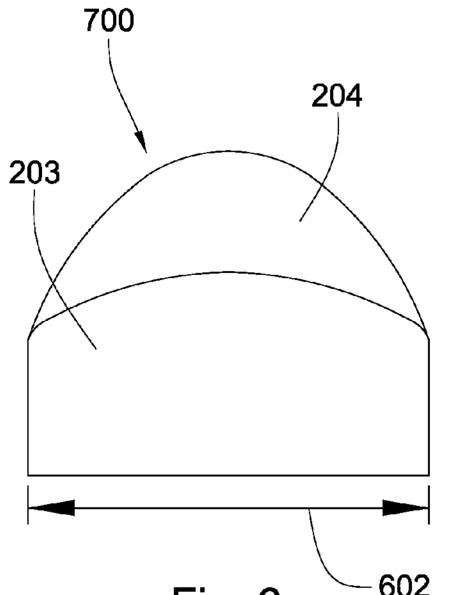

Fig. 6

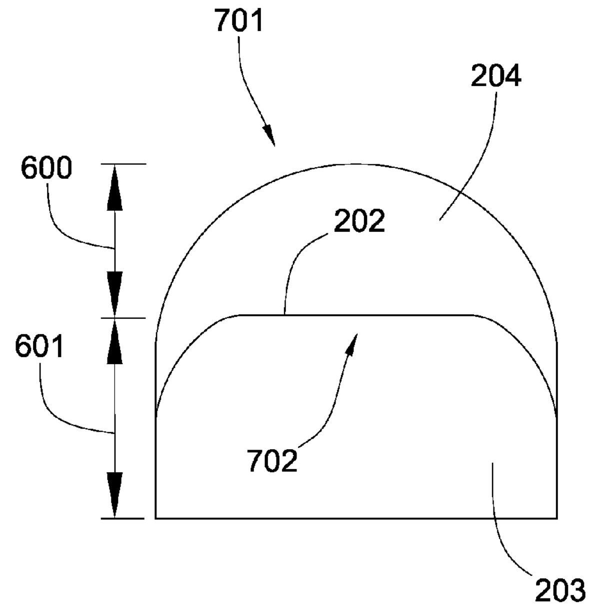

Fig. 7

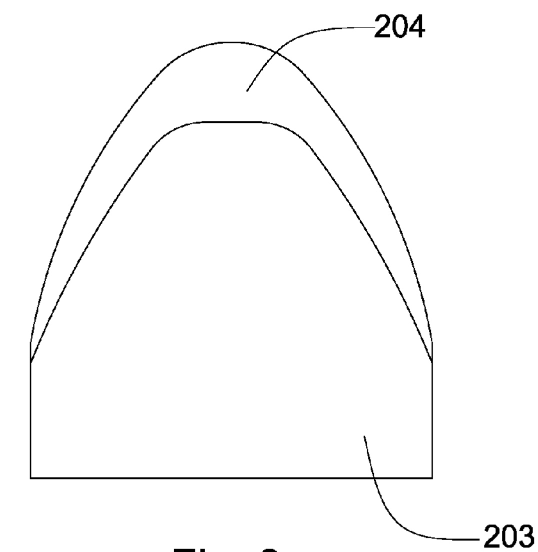

Fig. 8

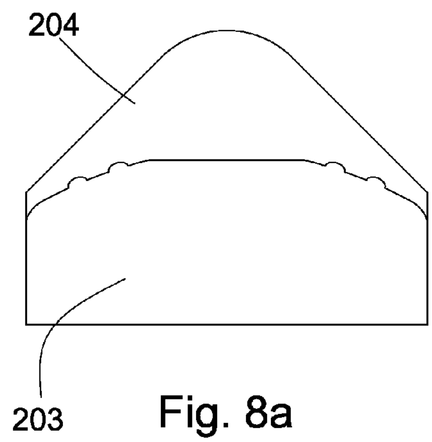

Fig. 8a

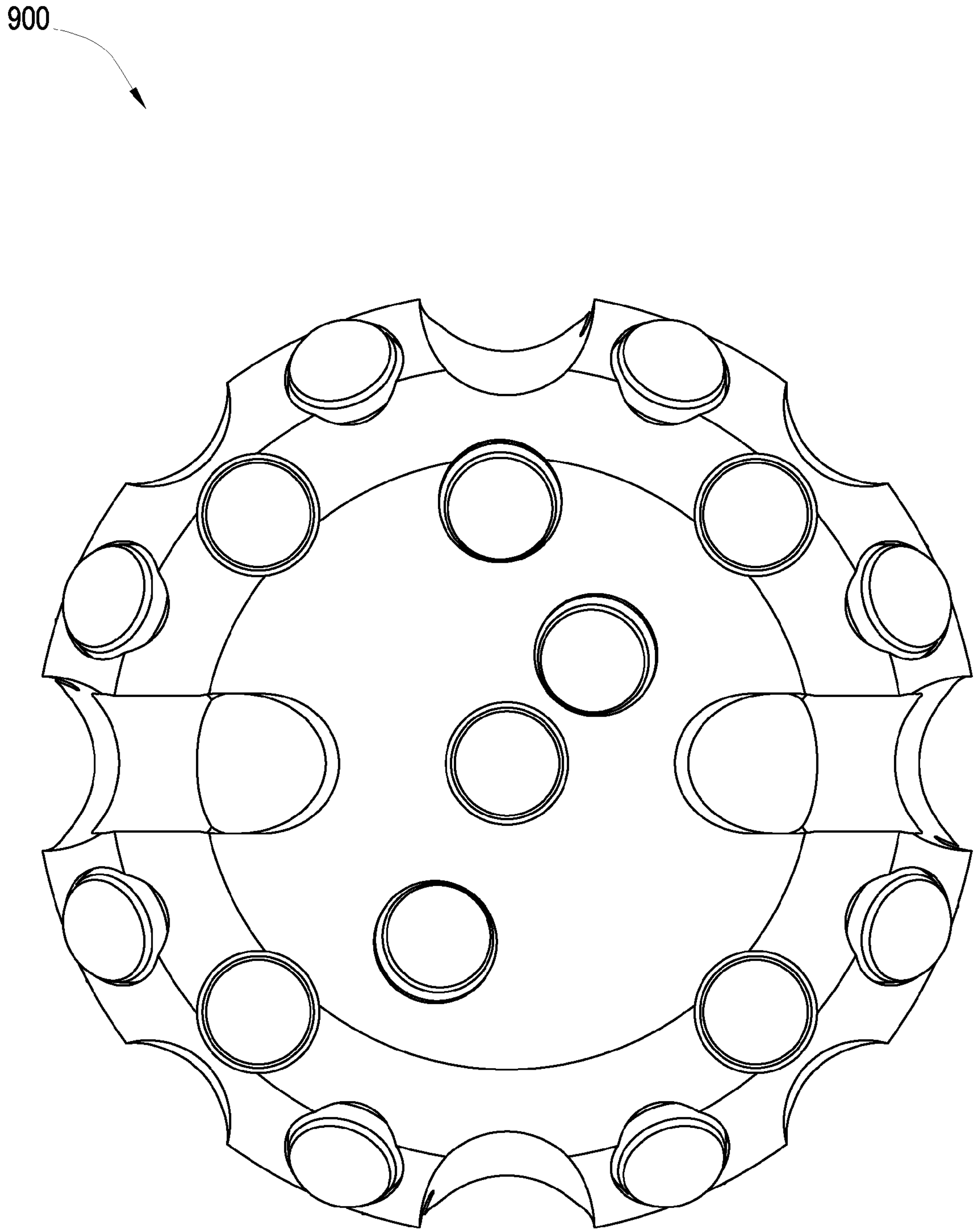

Fig. 9

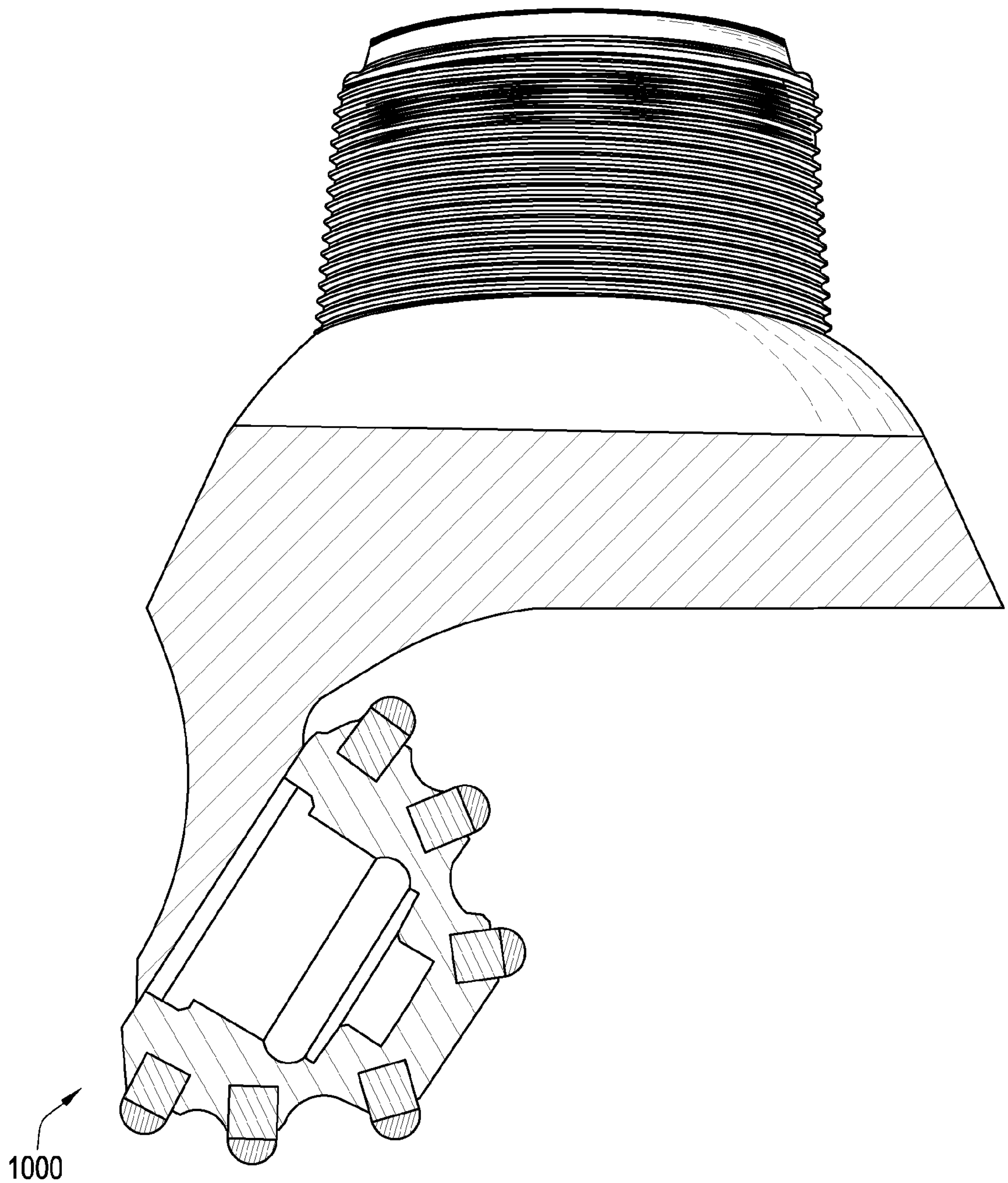

Fig. 10

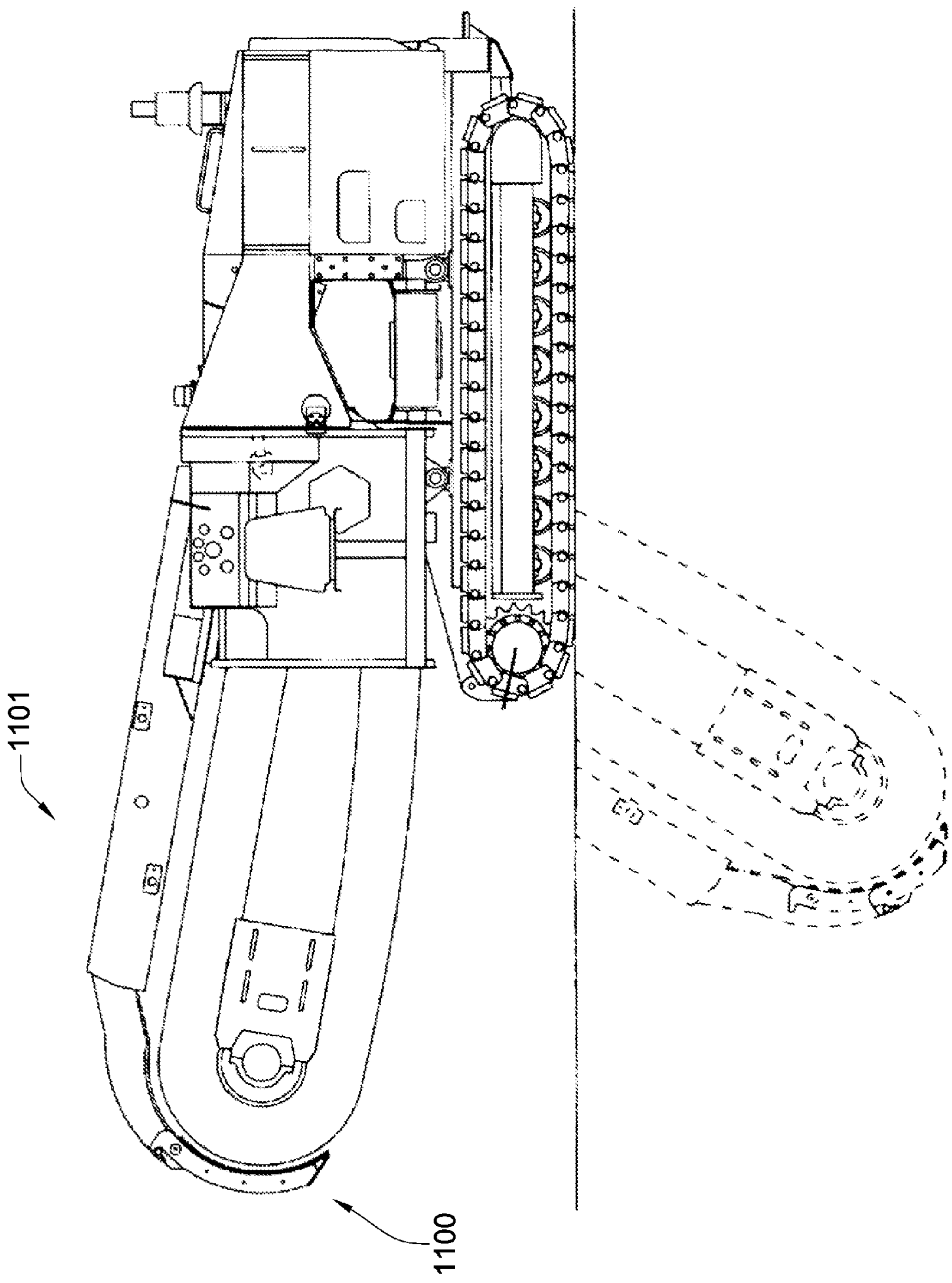

Fig. 11

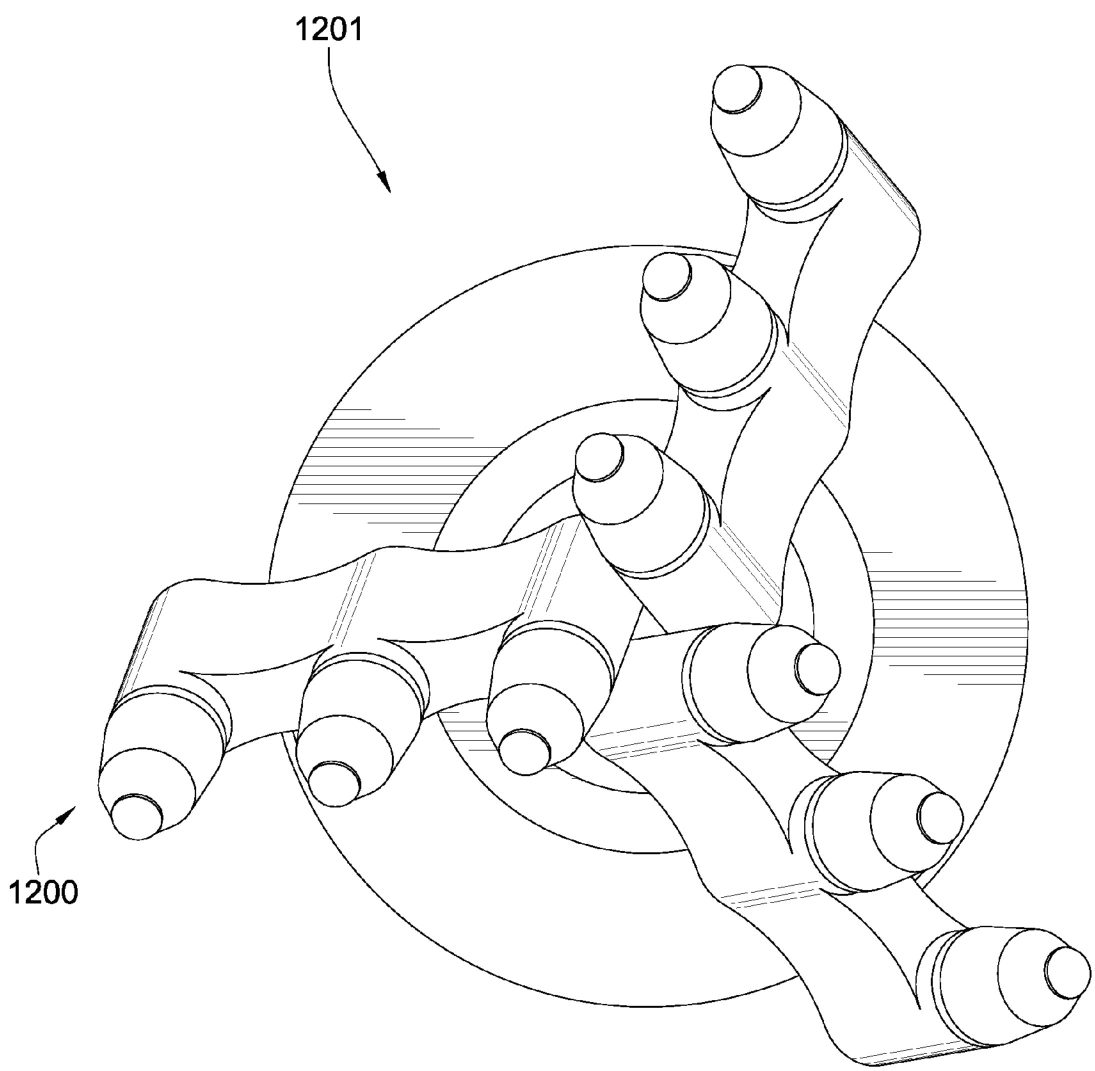

Fig. 12

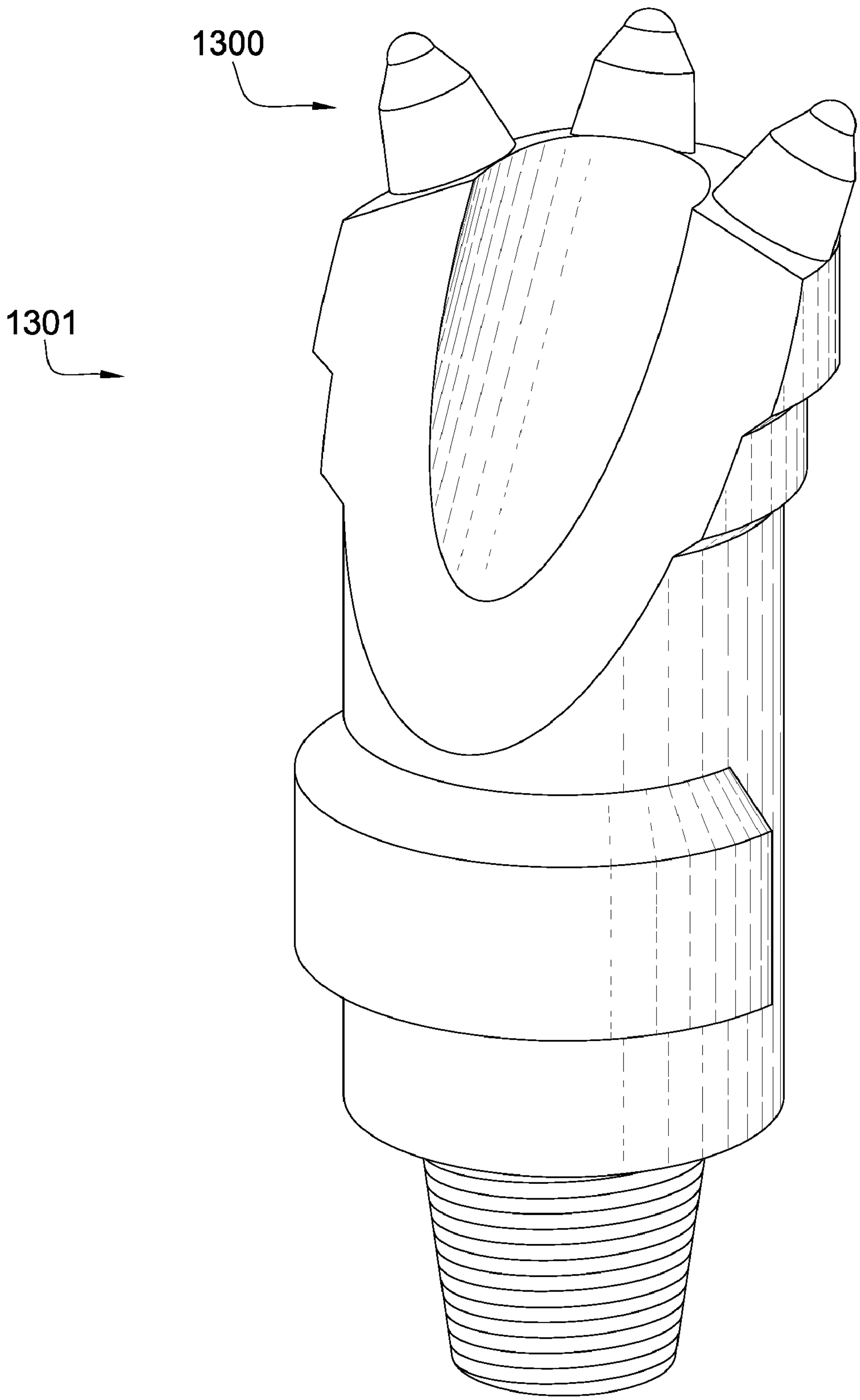

Fig. 13

TOOL WITH A LARGE VOLUME OF A SUPERHARD MATERIAL

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 11/553,338 which was filed on Oct. 26, 2006 and was entitled Superhard Insert with an Interface. U.S. patent application Ser. No. 11/553,338, which is herein incorporated by reference for all that it contains, is currently pending.

BACKGROUND OF THE INVENTION

The invention relates to an improved cutting element or insert that may be used in machinery such as crushers, picks, grinding mills, roller cone bits, rotary fixed cutter bits, earth boring bits, percussion bits or impact bits, and drag bits. More particularly, the invention relates to inserts comprised of a cemented metal carbide segment with a non-planar interface and an abrasion resistant layer of a superhard material affixed thereto using a high pressure high temperature press apparatus. Such inserts typically comprise a superhard material formed under high temperature and pressure conditions, usually in a press apparatus designed to create such conditions, cemented to a carbide segment containing a metal binder or catalyst such as cobalt. The segment is often softer than the superhard material to which it is bound. Some examples of superhard materials that high temperature high pressure (HPHT) presses may produce and sinter include cemented ceramics, diamond, polycrystalline diamond, and cubic boron nitride. A cutting element or insert is normally fabricated by placing a cemented carbide segment into a container or cartridge with a layer of diamond crystals or grains loaded into the cartridge adjacent one face of the segment. A number of such cartridges are typically loaded into a reaction cell and placed in the high pressure high temperature press apparatus. The segments and adjacent diamond crystal layers are then compressed under HPHT conditions which promotes a sintering of the diamond grains to form the polycrystalline diamond structure. As a result, the diamond grains become mutually bonded to form a diamond layer over the substrate face, which is also bonded to the substrate face.

Such inserts are often subjected to intense forces, torques, vibration, high temperatures and temperature differentials during operation. As a result, stresses within the structure may begin to form. Drill bits for example may exhibit stresses aggravated by drilling anomalies during well boring operations such as bit whirl or spalling often resulting in delamination or fracture of the abrasive layer or carbide segment thereby reducing or eliminating the cutting element's efficacy and decreasing overall drill bit wear life. The ceramic layer of an insert sometimes delaminates from the carbide segment after the sintering process and/or during percussive and abrasive use. Damage typically found in percussive and drag bits is a result of shear failures, although non-shear modes of failure are not uncommon. The interface between the ceramic layer and carbide segment is particularly susceptible to non-shear failure modes.

U.S. Pat. No. 5,544,713 by Dennis, which is herein incorporated by reference for all that it contains, discloses a cutting element which has a metal carbide stud having a conic tip formed with a reduced diameter hemispherical outer tip end portion of said metal carbide stud.

U.S. Pat. No. 6,196,340 by Jensen, which is herein incorporated by reference for all that it contains, discloses a cutting element insert provided for use with drills used in the drilling and boring through of subterranean formations.

U.S. Pat. No. 6,258,139 by Jensen, which is herein incorporated by reference for all that it contains, discloses a cutting element, insert or compact which is provided for use with drills used in drilling and boring subterranean formation or in machining of metal, composites or wood-working.

U.S. Pat. No. 6,260,639 by Yong et al., which is herein incorporated by reference for all that it contains, discloses a cutter element for use in a drill bit, having a substrate comprising a grip portion and an extension and at least a cutting layer affixed to said substrate.

U.S. Pat. No. 6,408,959 by Bertagnolli et al., which is herein incorporated by reference for all that it contains, discloses a cutting element, insert or compact which is provided for use with drills used in the drilling and boring of subterranean formations.

U.S. Pat. No. 6,484,826 by Anderson et al., which is herein incorporated by reference for all that it contains, discloses enhanced inserts formed having a cylindrical grip and a protrusion extending from the grip.

U.S. Pat. No. 5,848,657 by Flood et al, which is herein incorporated by reference for all that it contains, discloses domed polycrystalline diamond cutting element wherein a hemispherical diamond layer is bonded to a tungsten carbide substrate, commonly referred to as a tungsten carbide stud. Broadly, the inventive cutting element includes a metal carbide stud having a proximal end adapted to be placed into a drill bit and a distal end portion. A layer of cutting polycrystalline abrasive material disposed over said distal end portion such that an annulus of metal carbide adjacent and above said drill bit is not covered by said abrasive material layer.

BRIEF SUMMARY OF THE INVENTION

In one aspect of the invention, a tool has a wear-resistant base suitable for attachment to a driving mechanism and also a hard tip attached to the base at an interfacial surface. The driving mechanism may be attached to a milling drum, a drill pipe, a trenching machine, a mining machine, or combinations thereof. The tip has a first cemented metal carbide segment bonded to a superhard material at a non-planar interface. The tip has a height between 4 and 10 mm and also has a curved working surface opposite the interfacial surface. A volume of the superhard material is about 75% to 150% of a volume of the first cemented metal carbide segment.

In the preferred embodiment, the tip has a volume of 0.2 to 2.0 ml. The tip also has a rounded geometry that may be conical, semispherical, domed, or a combination thereof. A maximum thickness of the superhard material may be approximately equal to a maximum thickness of the first metal carbide segment. The superhard material may comprise polycrystalline diamond, vapor-deposited diamond, natural diamond, cubic boron nitride, infiltrated diamond, layered diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, or combinations thereof. The material may also be sintered with a catalytic element such as iron, cobalt, nickel, silicon, hydroxide, hydride, hydrate, phosphorus-oxide, phosphoric acid, carbonate, lanthanide, actinide, phosphate hydrate, hydrogen phosphate, phosphorus carbonate, alkali metals alkali earth metals, ruthenium, rhodium, palladium, chromium, manganese, tantalum or combinations thereof.

The first cemented metal carbide segment may have a diameter of 9 to 13 mm and may have a height of 2 to 6 mm. The carbide segment may also comprise a region proximate the non-planar interface that has a higher concentration of a binder than its distal region.

In some embodiments, the base has a second carbide segment that is brazed to the tip with a first braze that has a melting temperature from 800 to 970 degrees Celsius. The first braze has a melting temperature from 700 to 1200 degrees Celsius and comprises silver, gold, copper, nickel, palladium, boron, chromium, silicon, germanium, aluminum, iron, cobalt, manganese, titanium, tin, gallium, vanadium, indium, phosphorus, molybdenum, platinum, zinc, or combinations thereof. The second cemented metal carbide may have a volume of 0.1 to 0.4 ml and comprises a generally frustoconical geometry. The metal carbide segments may comprise tungsten, titanium, molybdenum, niobium, cobalt, and/or combinations thereof. The first end of the second segment has a cross sectional thickness of about 6 to 20 mm and the second end of the second segment has a cross sectional thickness of 25 to 40 mm. A portion of the superhard material is 0.5 to 3 mm away from the interface between the carbide segments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional diagram of an embodiment of attack tools on a rotating drum attached to a motor vehicle.

FIG. **2** is an orthogonal diagram of an embodiment of an attack tool.

FIG. **3** is an orthogonal diagram of another embodiment of an attack tool.

FIG. **4** is an orthogonal diagram of another embodiment of an attack tool.

FIG. **5** is an exploded perspective diagram of another embodiment of an attack tool.

FIG. **6** is a cross-sectional diagram of an embodiment of a first cemented metal carbide segment and a superhard material.

FIG. **7** is a cross-sectional diagram of another embodiment of a first cemented metal carbide segment and a superhard material.

FIG. **8** is a cross-sectional diagram of another embodiment of a first cemented metal carbide segment and a superhard material.

FIG. **8***a* is a cross-sectional diagram of another embodiment of a first cemented metal carbide segment and a superhard material.

FIG. **9** is a perspective diagram of an embodiment of an insert incorporated in a percussion drill bit.

FIG. **10** is a perspective diagram of an embodiment of a roller cone drill bit assembly.

FIG. **11** is a perspective diagram of an embodiment of an excavator including a trenching attachment.

FIG. **12** is a perspective diagram of an embodiment of an insert incorporated in a mining drill bit.

FIG. **13** is a perspective diagram of another embodiment of an insert incorporated in a drill bit.

DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

FIG. **1** is a cross-sectional diagram of an embodiment of attack tools **100** on a rotating drum **101** attached to a motor vehicle **102**. The motor vehicle **102** may be a cold planer used to degrade manmade formations such as pavement **103** prior to the placement of a new layer of pavement. In other embodiments the motor vehicle may be a mining vehicle used to degrade natural formations or an excavating machine. Tools **100** may be attached to a drum **102** as shown or in other embodiments a chain may be used. As the drum or chain rotate so the tools **100** engage the formation and thereby degrade it. The formation may be hard and/or abrasive and cause substantial wear on prior art tools. The wear-resistant tool **100** of the present invention may be selected from the group consisting of drill bits, asphalt picks, mining picks, hammers, indenters, shear cutters, indexable cutters, and combinations thereof.

FIG. **2** is an orthogonal diagram of an embodiment of an attack tool **100** comprising a base **200** suitable for attachment to a driving mechanism and a tip **201** attached to an interfacial surface **202** of the base **200**. The driving mechanism may be attached to a milling drum, a drill pipe, a trenching machine, a mining machine, or combinations thereof. The tip **201** has a first cemented metal carbide segment **203** that is bonded to a superhard material **204** at a non-planar interface **205**, the tip **201** having a curved working surface **206** opposite the interfacial surface **202**. The curved working surface **206** may be conical, semispherical, domed or combinations thereof. The tip **201** may comprise a height **207** of 4 to 10 mm and a volume of 0.2 to 0.8 ml. The first cemented metal carbide segment **203** may comprise a height **208** of 2 to 6 mm. The first metal carbide segment **203** comprises a region **209** proximate the non-planar interface **205** that has a higher concentration of a binder than a distal region **210** of the first metal carbide segment **203** to improve bonding or add elasticity to the tool. The volume of the superhard material **204** may be about 75% to 150% of the volume of the first cemented metal carbide segment **203**. In the some embodiments, the volume of the superhard material **204** is 95% of the volume of the first cemented metal carbide segment **203**. The superhard material **204** may comprise polycrystalline diamond, vapor-deposited diamond, natural diamond, cubic boron nitride, infiltrated diamond, layered diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bounded diamond, or combinations thereof. Also, the superhard material **204** may be sintered with a catalytic element comprising iron, cobalt, nickel, silicon, hydroxide, hydride, hydrate, phosphorus-oxide, phosphoric acid, carbonate, lanthanide, actinide, phosphate hydrate, hydrogen phosphate, phosphorus carbonate, alkali metals, alkali earth metals, ruthenium, rhodium, palladium, chromium, manganese, tantalum or combinations thereof.

In some embodiments, the first cemented metal carbide segment **203** may have a relatively small surface area to bind with the superhard material **204** reducing the amount of superhard material required and reducing the overall cost of the attack tool. In embodiments where high temperature and high pressure processing are required, the smaller the first metal carbide segment **203** is the cheaper it may be to produce large volumes of attack tool since more segments **203** may be placed in a high temperature high pressure apparatus at once.

FIG. **3** is an orthogonal diagram of another embodiment of an attack tool **100** with a first cemented metal carbide segment **203**. In this embodiment, the braze material has a melting temperature of 800 to 970 degrees Celsius. The second metal carbide segment **300** may have a first end **301** that comprises a cross sectional thickness of about 6 to 20 mm and a second end **302** that comprises a cross sectional thickness of 25 to 40 mm. The second carbide segment **300** and the tip **201** are brazed together with a first braze material

comprising a melting temperature from 700 to 1200 degrees Celsius. This first braze material may comprise silver, gold, copper, nickel, palladium, boron, chromium, silicon, germanium, aluminum, iron, cobalt, manganese, titanium, tin, gallium, vanadium, indium, phosphorus, molybdenum, platinum, zinc, or combinations thereof. The first braze material may comprise 30 to 60 weight percent nickel, 30 to 62 weight percent palladium, and 3 to 15 weight percent silicon. In embodiments, the first braze material may comprise 44.5 weight percent nickel, 45.5 weight percent palladium, 5.0 weight percent silicon, and 5.0 weight percent cobalt. In other embodiments, the braze material may comprise 47.2 weight percent nickel, 46.7 weight percent palladium, and 6.1 weight percent silicon. Active cooling during brazing may be critical in some embodiments, since the heat from brazing may leave some residual stress in the bond between the first cemented metal carbide segment **203** and the superhard material **204**. In some embodiments, the second braze material may be layered for easing the stresses that may arise when bonding carbide to carbide. Such braze materials may be available from the Trimet® series provided by Lucas-Milhaupt, Inc a Handy & Harman Company located at 5656 S. Pennsylvania Ave. Cudahy, Wis. 53110, USA.

A portion of the superhard material **204** may be a distance **303** of 0.5 to 3 mm away from an interface **304** between the carbide segments **203**, **300**. The greater the distance **303**, the less thermal damage is likely to occur during brazing. However, increasing the distance **303** may also increase the moment on the first metal carbide segment and increase stresses at the interface **304**. The metal carbide segments **203**, **300** may comprise tungsten, titanium, molybdenum, niobium, cobalt, and/or combinations thereof. The second metal carbide segment **300** comprises a generally frustoconical geometry and may have a volume of 1 to 10 ml. The geometry may be optimized to move cuttings away from the tool **100**, distribute impact stresses, reduce wear, improve degradation rates, protect other parts of the tool **100**, and/or combinations thereof.

FIG. **4** is an orthogonal diagram of another embodiment of an attack tool **100** with cemented metal carbide segments **203**, **300**. The second metal carbide segment **300** may have a smaller volume than that shown in FIG. **3**, helping to reduce the weight of the tool **100** which may require less horsepower to move or it may help to reduce the cost of the attack tool **100**.

FIG. **5** is an exploded perspective diagram of another embodiment of an attack tool **100**. The attack tool **100** comprises a wear-resistant base **200** suitable for attachment to a driving mechanism and a hard tip **201** attached to an interfacial surface **202** of the base **200**. The attack tool **100** also comprises cemented metal carbide segments **203**, **300** brazed together with a first braze **500** disposed in an interface **304** opposite the wear resistant base **200**, a shank **501**, and a second braze **502** disposed in an interfacial surface **202** between the base **200** and the second cemented carbide segment **300**.

Further, the second cemented metal carbide segment **300** may comprise an upper end **503** that may be substantially equal to or slightly smaller than the lower end of the first cemented metal carbide segment **203**.

FIGS. **6**-**8** are cross-sectional diagrams of several embodiments of a first cemented metal carbide segment **203** and a superhard material **204** wherein the superhard material **204** comprises a thickest portion **600** approximately equal to a thickest portion **601** of the first cemented metal carbide segment **203**. The thickest portion **600** of the superhard material **204** may comprise a distance of 0.100 to 0.500 inch. It is believed that the greater the distance is from the tip of the superhard material to the interfacial surface **202**, the less impact a formation will have on the first cemented metal carbide segment **203**. Thus, the superhard material **204** may self buttressed and not rely on the first cemented metal carbide segment **203** for support. The cemented metal carbide **203** may also comprise a diameter **602** of 9 to 18 mm. The interface **205** between the first cemented metal carbide segment **203** and the superhard material **204** may be non-planar. The superhard material **204** may comprise polycrystalline diamond, vapor-deposited diamond, natural diamond, cubic boron nitride, infiltrated diamond, layered diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, or combinations thereof. The superhard material **204** may comprise layers of varying concentrations of cobalt or of another catalyst such that a lower portion of the superhard material has a higher concentration of catalyst than a curved working surface of the superhard material. The superhard material **204** may be at least 4,000 HK and in some embodiments it may be 1 to 20000 microns thick. The superhard material **204** may comprise a region **603** (preferably near the curved working surface **206**) that is free of binder material. The average grain size of the superhard material **204** may be 10 to 100 microns in size.

The first cemented metal carbide segment **203** and the superhard material **204** may comprise many geometries. The superhard material **204** in FIG. **6** comprises a domed geometry **700**. FIG. **7** depicts the superhard material **204** comprising a generally conical geometry **701**. The generally conical geometry **701** may comprise a generally thicker portion **600** directly over a flat portion **702** of the interfacial surface **202**. In FIGS. **6** and **7** the superhard material **204** comprises a blunt geometry such that its radius of curvature is relatively large compared to a radius of curvature of superhard material with a sharper geometry. Blunt geometries may help to distribute impact stresses during formation degradation, but cutting efficiency may be reduced. The superhard material **204** in FIG. **8** comprises a conical geometry. The non-planar interface between the superhard material **204** and the first cemented metal carbide segment **203** may also comprise a flat portion. Sharper geometries, such as shown in FIG. **8** and FIG. **8***a*, may increase cutting efficiency. FIG. **8***a* comprises a 0.094 radius.

FIGS. **9**-**13** show the current invention depicting the insert with various embodiments as an insert **900** in a percussion drill bit **901**, an insert **1000** in a roller bit **1001**, an insert **1100** in an excavator **1101**, an insert **1200** in a mining drill bit **1201**, and an insert **1300** in a threaded rock bit **1301**.

Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

The invention claimed is:

1. A tool, comprising:

a wear-resistant base suitable for attachment to a driving mechanism and a hard tip attached to a second carbide segment which is attached to an interfacial surface of the base;

the tip comprising a first cemented metal carbide segment bonded to a superhard material at a non-planar interface;

the tip comprising a height of 4 to 10 mm and a curved working surface opposite the interfacial surface;

wherein a volume of the superhard material is about 75% to 150% of a volume of the first cemented metal carbide segment; and

wherein the first end of the second segment comprises a cross sectional thickness of about 6 to 20 mm and the second end of the second segment comprises a cross sectional thickness of 25 to 40 mm.

2. The tool of claim **1**, wherein the first cemented metal carbide segment comprises a diameter of 9 to 18 mm.

3. The tool of claim **1**, wherein the superhard material is selected from the group consisting of polycrystalline diamond, vapor-deposited diamond, natural diamond, cubic boron nitride, infiltrated diamond, layered diamond, diamond impregnated carbide, diamond impregnated matrix, silicon bonded diamond, and combinations thereof.

4. The tool of claim **1**, wherein the superhard material may be sintered with a catalytic element selected from the group consisting of iron, cobalt, nickel, silicon, hydroxide, hydride, hydrate, phosphorus-oxide, phosphoric acid, carbonate, lanthanide, actinide, phosphate hydrate, hydrogen phosphate, phosphorus carbonate, alkali metals, alkali earth metals, ruthenium, rhodium, palladium, chromium, manganese, tantalum and combinations thereof.

5. The tool of claim **1**, wherein the first cemented metal carbide segment comprises a height of 2 to 6 mm.

6. The tool of claim **1**, wherein the first cemented metal carbide segment comprises a region proximate the non-planar interface comprising a higher concentration of a binder than a distal region of the first cemented metal carbide segment.

7. The tool of claim **1**, wherein a volume of the tip is 0.2 to 2.0 ml.

8. The tool of claim **1**, wherein the curved working surface is conical, semispherical, domed or combinations thereof.

9. The tool of claim **1**, wherein the superhard material comprises a thickest portion approximately equal to a thickest portion of the first cemented metal carbide segment.

10. The tool of claim **1**, wherein the driving mechanism is attached to a milling drum, a trenching machine, a mining machine or combinations thereof.

11. The tool of claim **1**, wherein the driving mechanism is attached to a drill pipe.

12. The tool of claim **1**, wherein the second carbide segment and the tip are brazed together with a first braze comprising a melting temperature from 700 to 1200 degrees Celsius.

13. The tool of claim **12**, wherein the melting temperature is from 800 to 970 degrees Celsius.

14. The tool of claim **13**, wherein the first braze comprises a material selected from the group consisting of silver, gold, copper, nickel, palladium, boron, chromium, silicon, germanium, aluminum, iron, cobalt, manganese, titanium, tin, gallium, vanadium, indium, phosphorus, molybdenum, platinum, zinc, and combinations thereof.

15. The tool of claim **1**, wherein the first and second metal carbide segments comprise a metal selected from the group consisting of tungsten, titanium, molybdenum, niobium, cobalt, and/or combinations thereof.

16. The tool of claim **1**, wherein a portion of the superhard material is 0.50 to 3 mm away from an interface between the first and second carbide segments.

17. The tool of claim **1**, wherein the second cemented metal carbide comprises a volume of 0.1 to 10 ml.

18. The tool of claim **1**, wherein the second cemented metal carbide comprises a generally frustoconical geometry.

19. The tool of claim **1**, wherein the first and second metal carbide segments are generally coaxial.

* * * * *